Acoustic Assessment

Proposed Plan Change

Whenuapai Green

98-100, 102 Totara Road
Whenuapai, Auckland

Date: 19th December 2024
Prepared for: Neil Construction Limited
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Document Control

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Preamble

This report takes a “design” approach to managing effects within required amenity levels. Nevertheless, a descriptive assessment of effects is included in Section 14, covering both indoors and outdoors.

The subject site is in proximity to a military airport with specific noise characteristics. The noise profile of flight activities differs from the noise profile of ground activities. Flight activities have minimal noise effects on the subject site. As a reflection of this, the site is mostly outside the regulatory noise overlay for flight activities. In contrast, the airport operations include engine testing events that generate noise at night. Due to the difference between the two noise profiles, effects of engine testing events at night would not be adequately reflected in overall daily averages and require assessment of the noise event itself for protection of amenity. Section 8**Error! Reference source not found.** of this report details the standards and regulations that support (nay explicitly require) this.

Considering the significantly lower effects associated with flight activities, this assessment is focused on measures for protection of amenity from the highest noise levels from an event (i.e. 15-minute period of a representative engine testing event) at the most sensitive spaces (bedrooms and living rooms), especially during the most sensitive times (night-time). It goes by extension that if amenity is maintained in these areas during the highest levels at critical times, it would also be maintained during less critical or lower noise periods. In addition, amenity from noise pertains to both indoors and outdoors, and this assessment considers mitigation measures associated with both.

We also note the following to provide context and clarity around this report:

- Noise from airport activities is treated as environmental noise inherent to the characteristics and soundscape of the area.
- Noise propagation models and contours in this report represent a 15-minute period during engine testing close to the subject site. These do not represent the averaged day and night (Ldn) noise contours associated with overall/flight operations.
- Assessment for design of indoor amenity is conservatively based on free-field noise levels with no shielding from existing or future buildings taken into account.

1 Introduction

This report has been prepared to assess potential noise effects from the proposed plan change for the subject site at 98-100, 102 Totara Road to establish a Residential zone. The site for the proposed development is across two lots on the eastern side of Totara Road. The site is currently mostly vacant other than 1-2 storey, light framed residential buildings at the south-western corner, and the northern end of the site. In accordance with the Auckland Unitary Plan, the subject site is currently zoned *Future Urban Zone*. The Proposed Plan Change (**PPC**) would result in the subject site being zoned *Residential – Mixed Housing Urban*, allowing for potential future residential developments.

This report is intended as an acoustic assessment of potential noise effects that can be received and generated by activities that would be enabled by the proposed zoning. Assessment is made in context of compliance with applicable regulations, and consideration of effects in context of protection of amenity of occupants and, as a consequence, protection of the Royal New Zealand Airforce (RNZAF) Base Whenuapai from reverse sensitivity (i.e. complaints from future occupants.) Assessment is made against applicable standards for the subject site, including the Auckland Unitary Plan – Operative Version (**AUP-OP**). This report:

- Identifies noise and vibration generating and receiving activities both within the development and for the surrounding environment.
- Details relevant regulatory criteria and recommended guidelines pertaining to both compliance and amenity of the facility.
- Proposes strategies, mitigation measures, and potential regulatory controls to be taken into account to control amenity within the subject site, and the effects on surrounding sites and activities, including reverse sensitivity.

This report is based on information provided by:

- Urban Design Statement by Urban Acumen
- Engine Testing Noise Contours by Tonkin+Taylor dated 05/03/2021
- Noise from Aircraft by Malcolm Hunt Associates dated 24/08/2017
- Engine Testing Noise Logging and Analysis by Marshall Day Acoustics dated 14/04/2021
- Aircraft Noise Memo by Marshall Day Acoustics dated 11/10/2022

2 Site

2.1 Identification

The proposed 16.4ha development site is located within two lots on the eastern side of Totara Road:

- LOT 2 DP 81411 [98-100 Totara Road]
- LOT 1 DP 53062 [102 Totara Road]

The proposed facilities are limited to the area shown below. For ease of reference in this report, directional boundaries are noted in the figure below. For context, the subject site is circa 620m from the northern tip to the southern boundary.

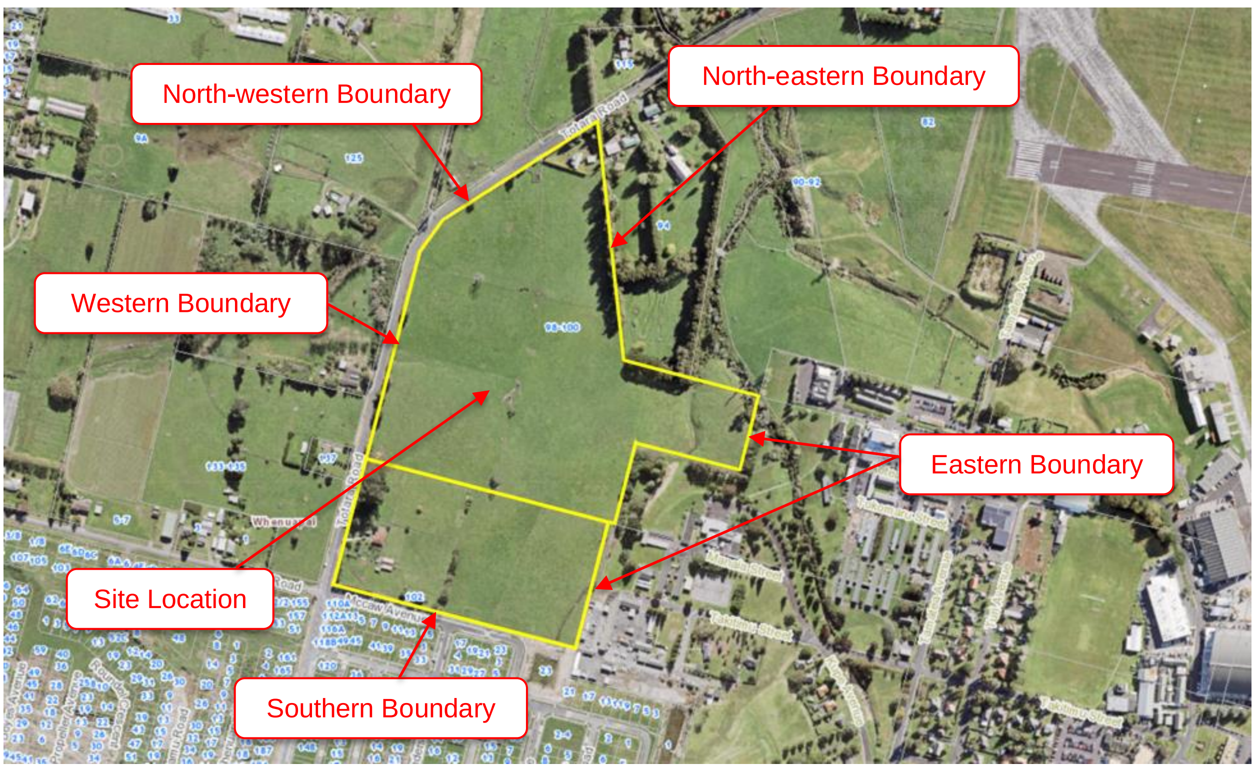

Figure 1 – Site Location – [AUP GeoMaps]

2.2 Zoning

In accordance with the Auckland Unitary Plan – Operative Version, the subject site and adjacent sites to the north, west and east are zoned *Future Urban Zone*. Sites to the south are zoned *Residential – Mixed Housing Urban Zone.* The Airbase to the east is zoned *Special Purpose – Airports and Airfields Zone.*

Figure 2 – Site Zoning – [AUP GeoMaps]

2.3 Topography

The site topography includes a slope up from the north-western and north-eastern boundaries to a central ridge circa 2-3m higher in elevation, then sloping up to the southern boundary where the elevation is circa 10m higher than the north-western and north-eastern boundaries.

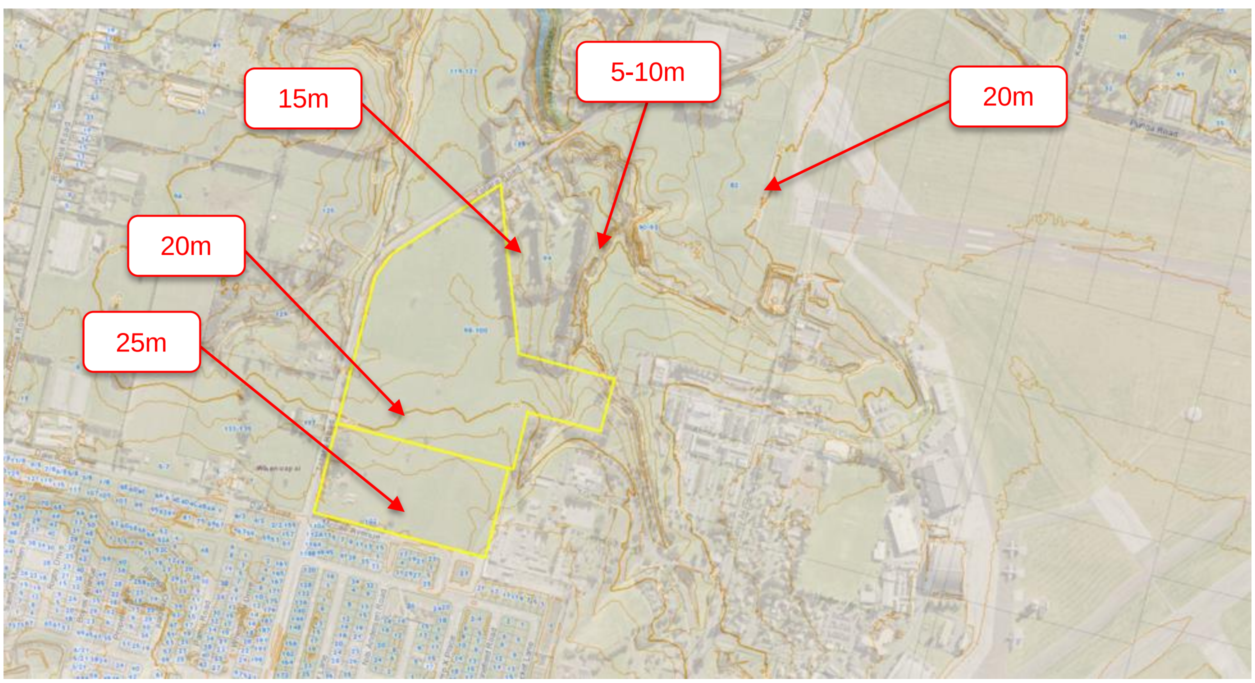

Figure 3 - Topography relative to airfield – [AUP Geomaps]

2.4 Vicinity

The neighbouring area adjacent to the subject site is of a generally rural characteristic with residential dwellings recently developed at the southern boundary. In context of noise and vibrations, the following sites are in the vicinity of the subject site, as shown in the figures below.

- **South:** Two storey residential dwellings, part of a recently developed residential neighbourhood of generally urban features. The development includes a business zone at the south-eastern end of the neighbourhood.
- **North, West:** Rural sites including residential buildings and ancillary support structures.
- **East:** RNZAF Base Whenuapai airbase, where facilities include:
    - **Runway (RWY) 08-26**, with the 08 threshold at circa 500m from the North-eastern (NE) boundary of the subject site. A taxiway (TWY) designated **TWY J (Juliet)** where engine testing is undertaken, is at the northern side of the 08 Threshold.
    - **Runway (RWY) 03-21 (Main runway)**, with the 03 threshold at circa 800m from the South-Eastern (SE) corner of the subject site. A taxiway (TWY) designated **TWY F (Foxtrot)** where engine testing is undertaken, is around the middle of the runway (slightly to the NE) where engine testing is undertaken at circa 1,100m from the easternmost point of the subject site.
    - **Hangars** located centre of the site with the closest at circa 550m from the subject site. We note the apron where low power aircraft operations occur is at the eastern side of the hangars away from the subject site.

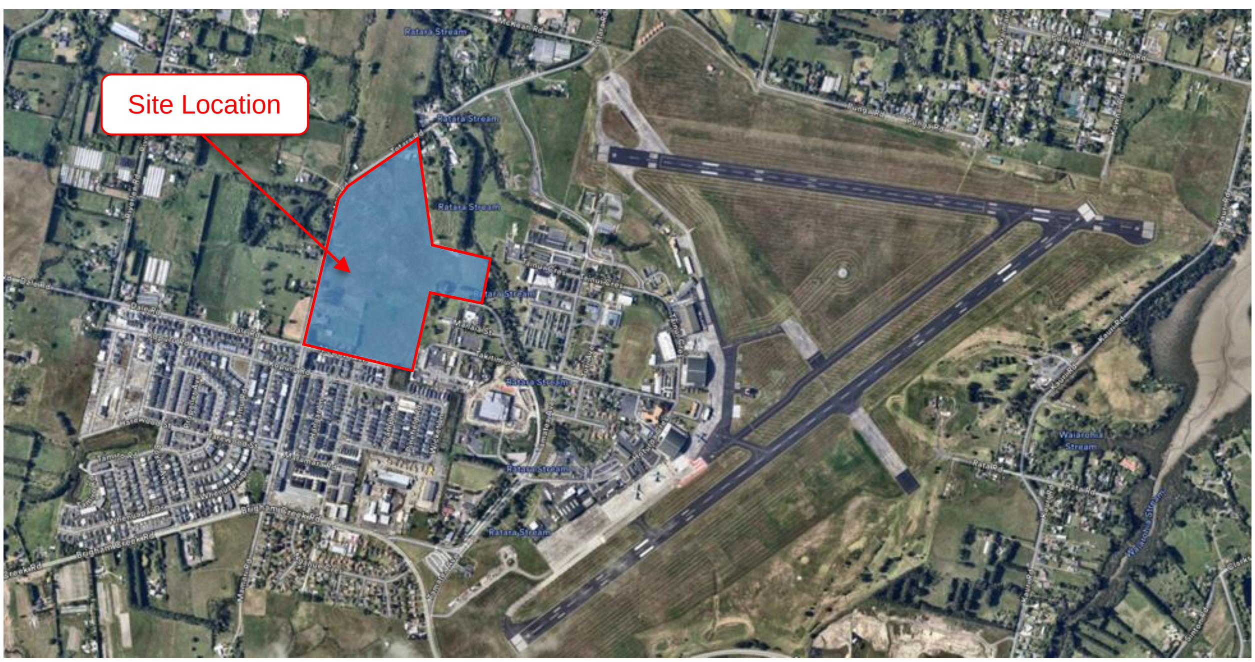

Figure 4 - Subject Site - [nearmap- 14/01/2024]

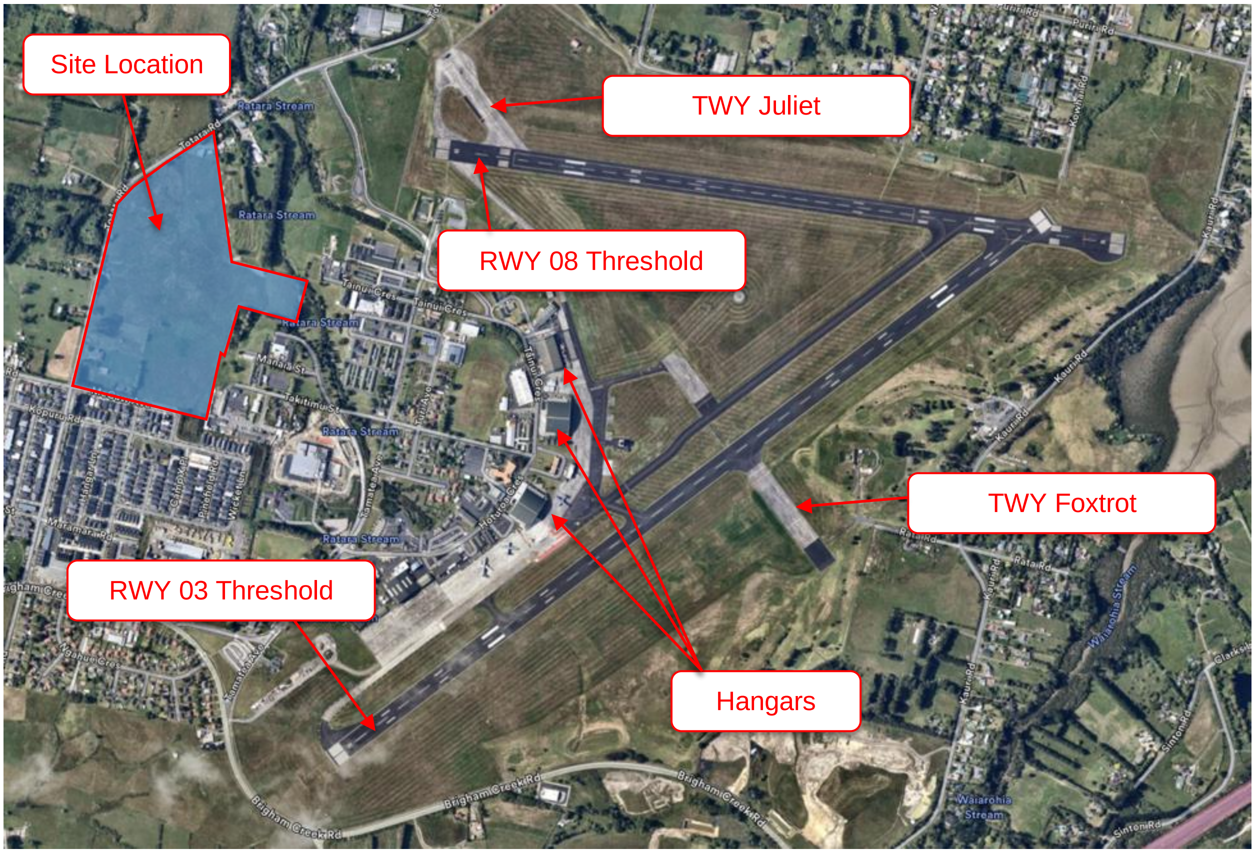

Figure 5 - Site Vicinity – [Nearmap – 14/01/2024]

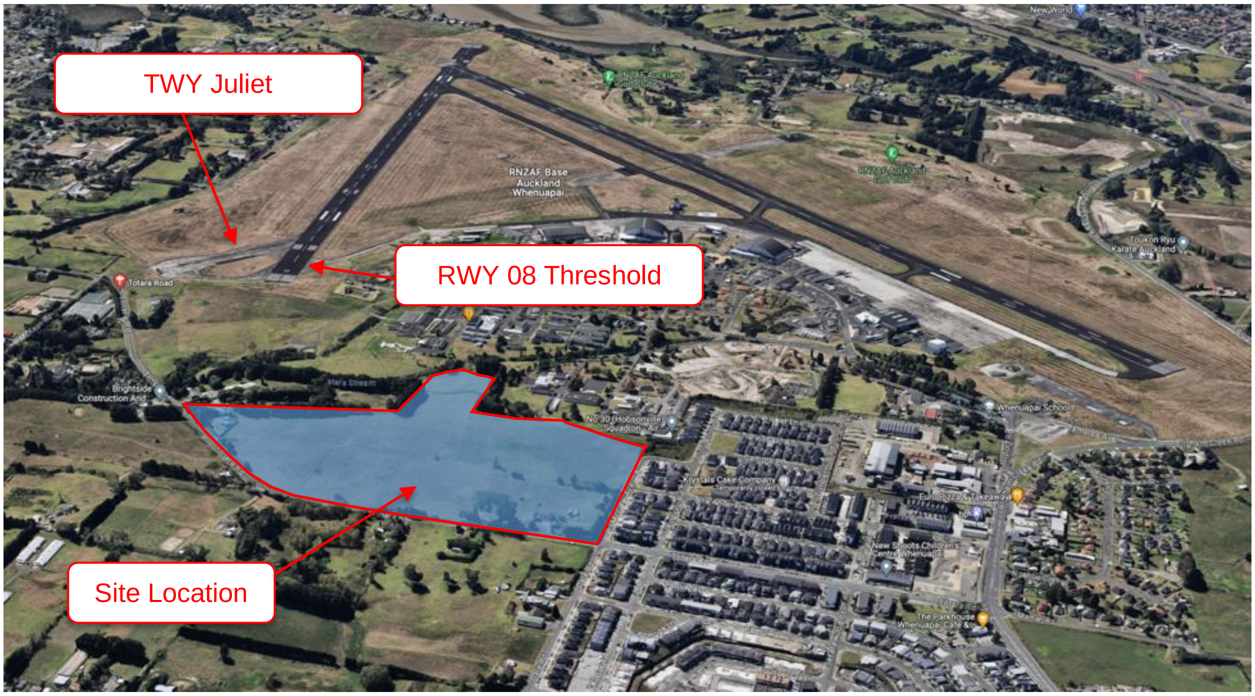

Figure 6 - Site Vicinity Aerial view for context of elevations – facing general East - [Google Earth]

3 Currently Applicable Regulatory Standards

In accordance with the Auckland Unitary Plan – Operative in Part (AUP-OP) the following standards apply to the subject site pertaining to the current zoning:

3.1 Noise Measurement and Assessment

In accordance with E25.6.1 of the AUP-OP the following applies to measurement and assessment of noise:

> *(1) Noise levels arising from activities must be measured and assessed in accordance with the New Zealand Standard NZS 6801:2008 Measurement of environmental sound and the New Zealand Standard NZS 6802:2008 Acoustics - Environmental noise except where more specific requirements apply.*

3.2 Noise Levels – Future Urban Zone

In accordance with the AUP-OP E25.6.3 the following applies for noise generated in a Future Urban Zone and received in sites similarly zoned:

E25.6.3. Noise levels in rural and future urban zones

(1) The noise (rating) level from any activity in the Rural – Mixed Rural Zone, Rural – Rural Production Zone, Rural – Rural Coastal Zone or the Future Urban Zone measured within the notional boundary on any site in any rural zone must not exceed the limits in Table E25.6.3.1 Noise levels in the Rural – Mixed Rural Zone, Rural – Rural Production Zone, Rural – Rural Coastal Zone or the Future Urban Zone below:

Table E25.6.3.1 Noise levels in the Rural – Mixed Rural Zone, Rural – Rural Production Zone, Rural – Rural Coastal Zone or the Future Urban Zone

Time	Noise level
Monday to Saturday 7am-10pm	55dB L_{Aeq}
Sunday 9am-6pm	
All other times	45dB L_{Aeq} 75dB L_{AFmax}

3.3 Aircraft Noise (Flights)

The subject site, with the exception of the northern-most 40m of the site, is outside the Airport Noise Overlay. The northern-most circa 40m of the site is within the L_{dn} 55dBA contour line (i.e. between L_{dn} 55dBA and L_{dn} 60dBA.)

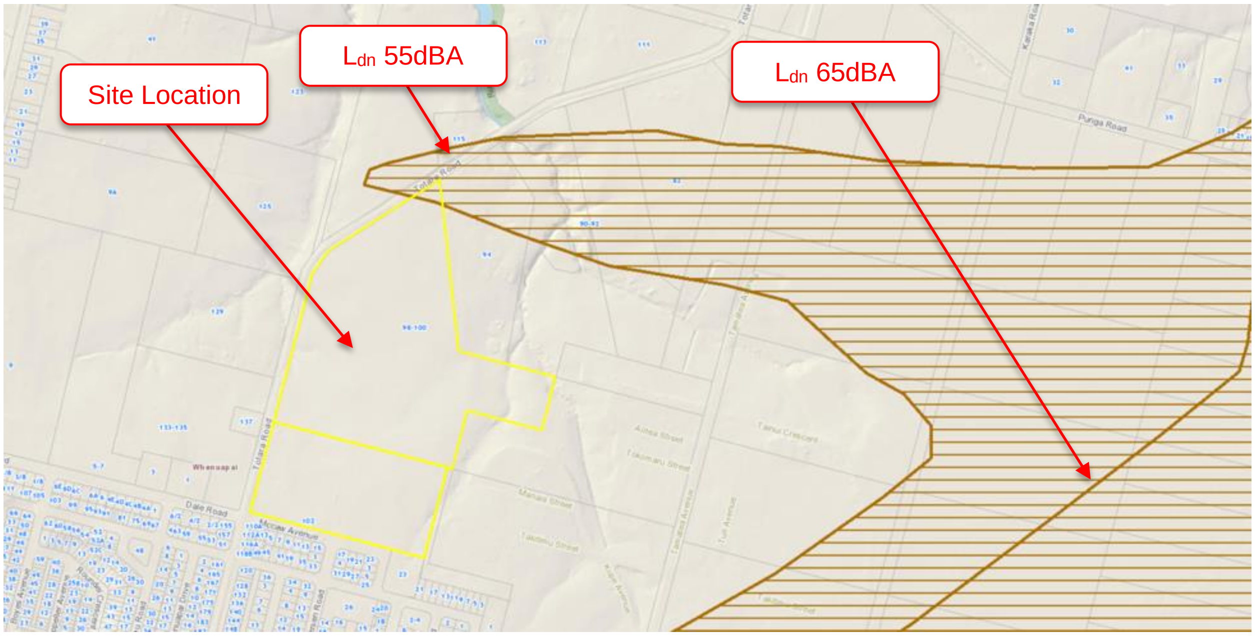

Figure 7 -Airport Noise Overlay - AUP-GIS

In accordance with the AUP D24 – Aircraft Noise Overlay, the following applies:

D24.4. Activity table

Except where more restrictive provisions apply in the underlying zoning or precinct, the following rules apply to activities sensitive to aircraft noise within the Aircraft Noise Overlay.

(1) Table D24.4.1 specifies the activity status of activities for the North Shore Airport, Kaipara Flats Airfield and Whenuapai Airbase pursuant to section 9(3) and section 11 of the Resource Management Act 1991.

Table D24.4.1 Activity table for North Shore Airport, Kaipara Flats Airfield and Whenuapai Airbase

Activity		Activity status
Development between the 55dB L_{dn} and 65dB L_{dn} noise boundaries (including Lot 3 DP 104718)		
(A1)	New activities sensitive to aircraft noise	RD
(A2)	New activities sensitive to aircraft noise that do not comply with Standard D24.6.1(1)	NC
(A3)	Alterations or additions to existing buildings accommodating activities sensitive to aircraft noise	RD
(A4)	Alterations or additions to existing buildings accommodating activities sensitive to aircraft noise that do not comply with Standard D24.6.1(1)	NC
Development within the 65dB L_{dn} noise boundary (excluding Lot 3 DP 104718)		
(A5)	New activities sensitive to aircraft noise	Pr
(A6)	Alterations or additions to existing buildings accommodating activities sensitive to aircraft noise	NC
Subdivision		
(A7)	Subdivision of land for activities sensitive to aircraft noise to create a new site within the 65dB L_{dn} noise boundary	Pr
(A8)	Subdivision of land for activities sensitive to aircraft noise to create a new site between the 55dB L_{dn} and 65dB L_{dn} noise boundaries	NC

D24.6.1. North Shore Airport, Kaipara Flats, and Whenuapai

(1) The following activities:

- D24.4.1(A1) New activities sensitive to aircraft noise; and
- D24.4.1(A3) Alterations or additions to existing buildings accommodating activities sensitive to aircraft noise

must provide sound attenuation and related ventilation and/or air conditioning measures:

(a) to ensure the internal noise environment of habitable rooms does not exceed a maximum noise level of 40dB L_{dn};

(b) that are certified by a person suitably qualified and experienced in acoustics to the Council's satisfaction prior to its construction; and

(c) so that the related ventilation and/or air conditioning system(s) satisfies the requirements of New Zealand Building Code Rule G4 with all external doors of the building and all windows of the habitable rooms closed.

4 Proposed Change – Regulatory Standards

4.1 Zoning Change

It is proposed that zoning of the subject site (comprising the two lots identified in Section 2.1) from the current _Future Urban Zone_ to _Residential – Mixed Housing Urban Zone._

4.2 Regulatory Standards Applicable to Change

In context of acoustics, the proposed change would result in the AUP Rule E25.6.2 applying instead of Rule E25.6.3. All other regulatory standards, in context of acoustics would apply with no change. As such, the following applies to the proposed zoning:

E25.6.2. Maximum noise levels in residential zones

(1) The noise (rating) levels and maximum noise level arising from any activity in the Residential – Large Lot Zone, Residential – Rural and Coastal Settlement Zone, Residential – Single House Zone, Residential – Mixed Housing Suburban Zone, Residential – Mixed Housing Urban Zone and the Residential – Terrace Housing and Apartment Buildings Zone measured

within the boundary of an adjacent site in these residential zones must not exceed the levels in Table E25.6.2.1 Noise levels in residential zones below:

Table E25.6.2.1 Noise levels in residential zones

Time	Noise level
Monday to Saturday 7am-10pm Sunday 9am-6pm	50dB L_{Aeq}
All other times	40dB L_{Aeq} 75dB L_{AFmax}

(2) The levels for the daytime hours in Table E25.6.2.1 Noise levels in residential zones may be exceeded by intermittent noise for reasonable periods where that noise is associated with normal household activities, such as lawn mowing or home handyman work.

5 Main Noise Sources

The main noise sources received by the subject site is associated with Aircraft operations are:

- Normal flight operations
- Emergency flight operations
- Ground based engine testing

The following is a general description, in context of noise, of these operations:

5.1 Normal Flight Operations (Taxiing, Take-off and Landing)

For arriving and departing aircraft (flights), noise levels received on the ground change with aircraft altitude, angle of elevation from receiver, throttle settings, wind conditions, glide path, etc. As the source of noise changes in altitude and location, receiver buildings cannot be shielded at ground level from noise of aircraft arrivals and departures. Noise contours for flight operations associated with Base Whenuapai are well established in the regulatory overlay in the AUP-OP.

While a military base would have less regularity of flight schedules compared to civilian airports, the nature of each aircraft movement is generally similar. Highest noise periods are short (in the order of a few minutes at most) during take-off and landing, potentially followed by short duration of overhead traversals. Longer periods between aircraft movements would have low noise activity.

5.2 Emergency Flight Operations (Taxiing, Take-off and Landing)

Emergency military operations are likely to be more intensive (more take-offs and landings in a short period) and may occur at unpredictable times including at night. While the operational profile (e.g. timing, frequency, ancillary activities, etc.) of emergency operations can differ from normal flight operations, the noise levels and characteristics associated with an emergency flight are generally similar to noise levels and characteristics of non-emergency flights.

5.3 Engine Testing

Noise levels from on-aircraft engine testing, in the environmental context, depend on a number of parameters including engine type, power setting, location and orientation of aircraft, meteorological conditions, elevation of engine, etc. Full engine test durations can be up to several hours, albeit the majority are usually circa 1-2 hours, with the highest noise levels usually not more than 50% of the time, albeit non-contiguous (e.g. testing two engines separately.) Max power tests for an engine are only undertaken for short durations of less than 5 minutes.

Testing of engines requires running one or more on-aircraft engines simultaneously at different throttle settings, including up to maximum power. Testing usually also requires running APUs (Auxiliary Power Units). Operationally, engine testing is undertaken under three general throttle ranges and can include throttle transitions across the full power range of an engine:

- **Idle (Low Power):** Engines can be run on idle at any location (including on aprons) and the setting can be maintained for long durations. All engines on an aircraft can be maintained at the idle setting simultaneously.
- **Pulling (Operating Power):** This represents a range of power settings and can be maintained for prolonged periods.
- **Full (Max Power):** This setting can only be maintained for short durations (up to 5 minutes)

Testing of engines on idle can be performed at multiple locations around base Whenuapai, including on the aprons adjacent the hangars. When high power settings are required, Engine testing at Base Whenuapai occurs mainly at the following locations:

- **TWY-J: Taxiway Juliet (closest) -** North of the threshold of Runway 08 (RWY 08.)
- **TWY-F: Taxiway Foxtrot (farthest):** South-East of the general centre of runway 21 - 03

In context of elevation, noise from engine testing occurs close to ground level, at elevations usually no more than 4m-5m. Noise propagation from engine testing is dependent on surrounding topography and can be affected at receivers by shielding, albeit this has to be close to a receiver to be effective. The frequency distribution of noise associated with engine testing differs between different engine types and varies around the engine. For example, jet engines have more low frequency content behind the engine than in-front of it. Nevertheless, two types of engine testing are relevant to the subject site with regards to the frequency distribution of noise (relative to the noise levels generated by each):

- **Jet Engine** noise is biased towards low frequency, distributed around the 63-500Hz.
- **Turbo Props** have similar low frequency biased noise to jet engines, albeit with a higher concentration of noise around the 125Hz frequency.

In context of this assessment the considerations of timing, duration, noise levels, frequencies, and occurrences of engine testing are discussed in detail in Section 7 of this report.

6 Acoustic Considerations

6.1 Noise Generated

The proposed change would result in a residential zone, which would be unremarkable in context of noise generated. Furthermore, the proposed residential zone would be required as per E25.6.2 of the AUP to generate lower noise levels (L_{eq} 5dBA less) than are currently allowed for in E25.6.3 pertaining to the existing Future Urban Zone. As such, effects of potential noise generated by the proposed change do not warrant further assessment.

6.2 Noise Received

It is our opinion that the different types of noise received (i.e. flight operations vs engine testing) warrant different assessment methodologies, taking into account applicable regulatory criteria (e.g. the AUP) with reference to amenity standards (e.g. NZS 2107 – Recommended Design Sound Levels for building interiors.)

As such, assessment for each type of noise received is considered below in context of both **Compliance** (objective) and **Effects** (subjective), and where the two are aligned, this is noted.

6.3 Reverse Sensitivity

Reverse sensitivity is the legal vulnerability of existing established activities to complaints from introduction of new land use activities in the vicinity. Complaints from new land use can arise against established activities regardless of whether these established activities are compliant or not.

Reverse sensitivity can arise from a lack of awareness of new occupants of the existing noise environment. As detailed further in this report, we recommend the titles and any associated tenancy agreements within the subject site include a no-complaints covenant for the benefit of RNZAF. While the covenant would have legal weight in context of reducing complaints, another main benefit is to ensure all occupants are clearly and formally aware that the noise characteristics of the area involve aviation related noise, including engine testing, prior to occupying any dwellings.

As a long-established military aviation facility undertaking activities of national importance, the onus would be on proposed new activities in the vicinity to, in so far as practicable, mitigate the effects of the noise and protect the existing established activities from legal vulnerability to complaints.

7 External Noise Assessment Methodology

7.1 Emergency Operations

While military aircraft operations during an emergency are not explicitly covered in regulatory standards, we note the following provision of the AUP for context:

- As per E25.6.1.(4) of the AUP, *"The noise limits of the Plan do not apply to emergency service sirens and callout sirens during emergency situations."*
- As per E25.6.32 of the AUP, "*The take-off or landing of a helicopter on any site* ***except for emergency services*** *must not exceed […]"*

Taking the above into account, it is reasonable to infer that safety in emergency situations takes precedence over amenity. As such, the operation of military aircraft during an emergency (e.g. rescue operations) cannot, and should not, be subject to amenity considerations, and as such do not warrant assessment or consideration.

Based on the above, amenity concerns and/or complaints pertaining to emergency operations should not be entertained or allowed regardless of effects on amenity. This can be reflected, implicitly or explicitly in a no-complaints covenant.

7.2 Engine Testing Compliance Discussion

For compliance purposes, the AUP uses L_{dn} contours for aircraft operations, albeit this only pertains to aircraft movements not engine testing. L_{dn} is the adopted noise descriptor by the U.S. Federal Aviation Authority (FAA) for flight operations (aircraft movements) and is commonly used in New Zealand regulatory controls for noise around airports.

As such, it would be the de facto approach to associate compliance standards for any airport noise with the same descriptor (notwithstanding the discussion below on amenity.) Based on the Marshall Day measurements of 2021, the site would be exposed to engine testing noise from TWY Juliet and TWY Foxtrot. Noise levels from Juliet would be higher due to proximity, but the high noise events from Foxtrot would be more frequent.

In accordance with the Ldn Engine Testing Noise Contours[1] (Reference Figure D2 – *NZDF Whenuapai Airbase – Engine Testing Contours – PC5* by Tonkin+Taylor dated 7/07/2021) the subject site is outside the L_{dn} 57dB Noise Contour, and a such would not require further design considerations in this context, other than the requirement if any dwelling is established on or inside the contour line to achieve an internal noise level of L_{dn} 40 dBA in habitable spaces.

[1] Report: Engine Testing Noise Contours by Tonkin+Taylor dated 05/03/2021

7.3 Engine Testing Effects Discussion

It is our opinion that the L_{dn} descriptor is not well suited, in the context of amenity, for the characteristics of noise from engine testing, as the duration of noise is prolonged (in the order of hours) and the occurrence of testing events is irregular and highly inconsistent (occurs some days, but not others, and may only occur one time in a day.)

The L_{dn} measure is best suited for regular noise events occurring day or night and reflects the cumulative exposure a person receives in a 24hr period from repeated instances of noise. It is not ideal to describe noise that occurs continuously (steady or fluctuating) for periods in the order of hours, in many cases only once a day.

Without mitigation measures (e.g. upgraded building envelope), internal noise levels during noise tests would not be tolerable for long periods even during daytime, and people would seek respite. The fact it occurs for durations in the order of hours at night warrants consideration of mitigation to reduce internal noise to within tolerable levels.

Putting technicalities aside, we find it makes more sense to design protections for occupants from noise occurring almost continuously for hours based on the higher noise levels during these hours, rather than averaging these hours over the rest of the day when no activity occurs, and providing protection based on that.

If noise occurs for a few minutes, then quiets down for a while, repeating throughout the day then averaging over a day would be reasonable. This is not the case here however, and as such reliance on LA_{eq} for amenity assessment is recommended.

As per the above, this assessment adopts the following objectives:

Assessment Objective
• **Indoor Amenity:** Control of internal noise levels to within established amenity levels in noise sensitive habitable spaces, during the most noise sensitive night-time periods, based on the highest environmentally representative external noise levels from engine testing received at different areas within the subject site. • **Outdoor Amenity:** Mitigation of noise in outdoor living spaces in so far as practicable.

8 Assessment Parameters

Based on the discussion in the previous section, the following parameters are adopted in this report to assess external noise in context of both compliance and effects:

- **Compliance:** Assessed based on **L_{dn} Contours** (Engine Testing and flight)
- **Effects:** Assessed based **LA_{eq} (15min)** based on:
  - 5 minutes at max power and 10 minutes at high power
  - Highest measured noise levels from TWY Juliet
  - Highest noise generating aircraft type during monitored periods.
  - Point source at an elevation of 4m

The reasoning and regulatory references underlying these assessment parameters are detailed in the following sections.

8.1 Noise Descriptors

The day and night averaged measure of noise (L_{dn}) is typically associated with aviation noise, where the noise exposure over a full day and night is averaged, including a penalty correction for night-time noise, to characterise noise by a single number (dBA.)

Typically, aviation related noise around airports constitutes regular occurrences (e.g. every few minutes near major civilian airports) of short duration noise (less than 1 minute) that gradually increases to its peak and decreases back during that short duration. The Ldn metric is usually ideal to describe this soundscape.

It is our opinion that the L_{dn} descriptor is not well suited, in context of amenity, to the characteristics of noise from engine testing. The duration of noise during engine testing is prolonged (in the order of hours) and the occurrence of testing events is irregular and highly inconsistent (occurs some days, but not others, and may only occur one time in a day.)

A more commonly used metric associated with sustained (steady fluctuating) environmental noise is the L_{eq} descriptor which integrates noise over a designated period of time to account for both the noise levels and durations of these noise levels, resulting in a single number (dB or dBA) that represents the human response and perception of the subject noise.

Considering the nature, level and duration of engine testing noise it is our recommendation to assess noise in context of amenity using the LA_{eq} noise descriptor. This is supported by regulatory standards as follows:

In accordance with Clause 1.4.3.6 of NZS 6805[2]:

> *"[…] For smaller airports or* ***airports with infrequent or irregular daily usage patterns****, planning on the basis of* ***sound exposure contours may not provide an adequate protection*** *area around the airport to avoid sleep disturbance. Local authorities* ***shall also consider the available data on noise levels for the noisiest aircraft types*** *which it is anticipated will use the airport."*

In accordance with Clause 1.2.2 of NZS6802[3]:

> *"[…] sound from airport activities except from aircraft taxiing and in-flight are within the scope of this standard."*

In accordance with NZS6801[4] Section 8 – Determination of Sound Descriptors:

> "*8.3 Steady sound with stepped variations of level:*
>
> *"Sound that is steady, but occurs at a number of clearly distinguishable levels, is measured either directly (as for a steady sound) or the LEQ may be determined from a series of measurements of the levels using equation 8, provided the durations of the individual levels are known:*

$$LA_{eq(t)} = 10 \times Log\left[\frac{1}{t}(t_1 10^{0.1LA_{eq(t1)}} + t_2 10^{0.1LA_{eq(t2)}}) + \cdots + t_N 10^{0.1LA_{eq(tN)}}\right]$$

Where:

N	*is the number of stepwise variations in level*
t_i	*is the time interval of the* i^{th} *step*
$LA_{eq(ti)}$	*is the* L_{eq} *of the* i^{th} *step*
t	*is the total time of measurements:* $t_1+t_2+\ldots+t_N$
$LA_{eq(t)}$	*is the* L_{eq} *over the total time t*

The above equation is used on the calculation of a representative highest noise level, and the consideration of the interval is detailed in the following section.

As such, this assessment adopts the following methodology:

Amenity assessment of "human response" to assess noise and mitigation based on a representative high noise level period during testing, with the **descriptor being** $\mathbf{LA_{eq}}$.

[2] NZS 6805:1992 – Airport Noise Management and Land Use Planning
[3] NZS 6802:2008 – Acoustics – Environmental Noise
[4] NZS6801-2008 – Acoustics – Measurement of Environmental Sound

8.2 Assessment Interval (time period)

With regards to the assessment interval, it is our opinion that a 15-minute time averaging period, as per the recommendations of NZS6802[5] would be appropriate provided it includes 5 minutes of max power (which is generally the longest max power is held for during testing) and 10 minutes of pulling power to conservatively represent the upper end of noise in any 15-minute period. This is supported by regulatory standards as follows:

In accordance with NZS 6802:2008[6], 6.2.2 the following applies:

> *"6.2.2 Simple Method*
> *The simple method should be used where:*
> *(a) The sound under investigation is continuously present for more than 15minutes and it is practical to directly measure a representative Leq value for a nominal 15-minute measurement time interval"*

In accordance with NZS 6802:2008[4], C5.2 the following applies:

> *"When using the simple method to determine a rating level, the measurement time interval should generally be 15 minutes"*

In accordance with NZS 6802:2008[4], *A2 Measurement Time Intervals and Sample Sizes*, pertaining to the nature of engine testing noise

A2.1: Suggested measurement time intervals are shown in table A1:

Temporal Nature	*Greatest Anticipated Range*		
	<5dB	*5-10dB*	*10-30dB*
Steady Continuous	*2 min*	*10min*	*n/a*
Fluctuating Continuous	*15 min*	*15min*	*15min*
Impulsive Continuous			

As per the above and considering the nature of engine testing noise, it is appropriate to use a 15-minute time interval for assessment:

Representative time interval of **15 minutes** comprising:

- **5 minutes of max power**
- **10 minutes of pulling power.**

[5] NZS6802-2008 – Acoustics – Environmental Noise
[6] NZS6802-2008 – Acoustics – Environmental Noise

8.3 Noise Profile (occurrence, duration, fluctuation)

8.3.1 Pertaining to Indoor Amenity

As per the above sections, assessment is based on a representative high noise event over a period of 15 minutes. In context of assessment of internal amenity, once the higher noise levels are mitigated sufficiently for the most sensitive receivers (time and location), lower noise levels, and less sensitive periods would also be mitigated sufficiently regardless of duration of instances, number of occurrences, or fluctuation of noise other than the representative maximum. As such, in context of amenity indoors, duration, fluctuation and number of occurrences can be disregarded. We note for reference that **no** duration adjustment will be included in the assessment for indoor amenity as the noise can occur during night times. This is supported by regulatory standards as follows:

In accordance with NZS6802:2008, 6.4 Duration, the following applies:

> *"6.4.1 […] because of the importance of protecting sleep, no adjustment is allowed during a prescribed time frame defined in a consent condition, rule or national environmental standard as night-time (for example 2200h to 0700h the following day)"*

8.3.2 Pertaining to Outdoor Amenity

With regards to outdoor noise amenity, assessment is made against daytime noise when outdoor living spaces would be used. We note the following regarding outdoor noise:

Based on the noise logging undertaken by Marshall Day Acoustics in 2021[7] collated with the noise monitoring undertaken by Tonkin + Taylor[8], it is our understanding that Engine testing occurs on circa 50%-75% of days ("days" being a reference to 24 hours, rather than daytime which is a reference to the time of day) with multiple tests potentially occurring during a day. Testing during night-time is understood to occur in circa 25% of days.

We assume a worst-case scenario of 3 engine tests done in one daytime period, with each having a duration of two hours, resulting in a total of 6 hours. For a residential zone where daytime hours are 0700 to 2200, this would represent noise being present for 40% of the time.

In accordance with NZS 6802:2008[9] 6.4.3 an adjustment of -3dB (less than 50% of the time) would be warranted for assessment of effects of outdoor noise[10].

- **Indoor Amenity:** No adjustment for external noise levels
- **Outdoor Amenity:** An adjustment of -3dBA for noise present for < 50% of the time.

[7] Engine Testing Noise Logging and Analysis by Marshall Day Acoustics dated 14/04/2021
[8] Engine Testing Noise Contours by Tonkin+Taylor dated 05/03/2021
[9] NZS6802-2008 – Acoustics – Environmental Noise
[10] NZS6802-2008 – 6.4.1

8.4 Noise Source Elevation

For modelling purposes, we recommend the noise source from engine testing is a 4m elevation point source. While we note the noisier jet engines (associated with the highest noise levels) are usually at lower elevations above ground level (with a centre at circa 2.5m above ground level,) it would be reasonable to assume noise is generated from the full height of the engine, where a point source at 4m elevation would be conservatively representative of the source.

- **Noise Source Modelling:** Point source at 4m elevation above ground level.

8.5 Aircraft Types

Noise levels from engine testing vary significantly between different types of aircraft and engine and varies based on the age and generation of aircraft.

We recommend using the highest noise levels associated with the aircraft types in use during the periods monitored notwithstanding the fact these are all based on older aircraft likely to either be already retired or retiring soon.

Newer aircraft generally emit materially lower noise levels than older generations of similar aircraft. For example, typical short and medium haul jet aircraft made after 2015 generate levels in the order of 8-10EPNdB lower than similar sized 1970s aircraft[11].

While newer aircraft of comparable size and function generate materially less noise than older aircraft, assessment against the higher noise levels associated with older aircraft provides a safety margin in terms of required mitigation measures. In addition, assessment against the higher noise levels of older aircraft provides futureproofing in case the RNZAF introduces larger or higher noise generating aircraft (e.g. heavy lift transport, or combat wing fighter jets) in the future.

- **Aircraft Type:** Use highest representative measured noise levels from aircraft in use during monitoring periods. While newer aircraft generate materially less noise, assessing mitigation requirements based on older aircraft provides a safety margin and future proofing in case larger or noisier aircraft types are introduced in the future.

[11] Eurocontrol - https://www.eurocontrol.int/ as referenced in M. Durgut, Aviation File, 20/01/2021, https://www.aviationfile.com/noise-pollution-levels-by-aircraft-types/

8.6 Directionality (aircraft orientation) and Meteorological Conditions

Noise levels received at a specific location in the vicinity of an engine test can vary significantly from one test to the next for the same aircraft and engine. This is due to the varying orientation of the aircraft during the test, as aircraft are pointed into the wind during max power tests, and with wind direction changing, the aircraft may be at different orientations during different tests. Noise levels vary around an aircraft, with the variability of the noise also dependent on the type of aircraft.

It is our opinion that the use of the highest representative noise levels as measured empirically during the monitored periods, and collated between the different monitoring periods, would be representative of the highest level associated not just with the aircraft type, but also with the orientation and meteorological conditions. While it would be theoretically possible to estimate variations of noise levels based on aircraft orientation and weather, this would not be practicable in context of a regulatory framework.

- **Aircraft Orientation and Meteorological Conditions:** use of the highest representative noise levels as measured empirically during the monitored periods, and collated between the different monitoring periods, would be representative of the highest level associated not just with the aircraft type, but also with the orientation and meteorological conditions.

8.7 Audible Characteristics (tonality, impulsiveness)

In accordance with Standard NZS 6802:2008, consideration should be given to special audible characteristics of noise (impulsiveness, tonality, etc.) as follows:

> *"Where the sound being assessed has a distinctive character which may affect its subjective acceptability (for example it is noticeably impulsive or tonal) the representative sound level shall be adjusted to take this into account. The adjustment shall be determined in accordance with the provisions of Appendix B"*

Based on the above, and where tonality is observed in noise sources as per the relevant standards, a penalty shall be incurred (arithmetically added) to any noise predictions or measurements as detailed in NZS 6802:2008 Appendix B, as follows:

- *"B4.5 Where special audible characteristics are confirmed, the value of the adjustment shall be 5 dB"*

We note the nature of noise from engine testing is not impulsive. With regards to tonality, and in accordance with B4.3 of NZS 6802:2008 Appendix B, the following test method for tonality applies:

"B4.3 A test for the presence of prominent discrete frequency spectral component (tonality) can be made by comparing the levels of neighbouring on-third octave bands in the sound spectrum. An adjustment for tonality shall be applied if the LEQ in one-third octave band exceeds the arithmetic mean of the LEQ in both adjacent bands by more than the values given in table B2"

Table B2 – One-third octave band level differences

One-third octave band	*Level difference*
25 – 125 Hz	*15 dB*
160 – 400 Hz	*8 dB*
500 – 1000 Hz	*5dB*
Note – At frequencies below 500 Hz the criterion could be too severe and tones might be identified where none is actually audible. For complex spectra the method is often adequate and the reference method should be used.	

As per the above, and with reference to published data[12] pertaining to noise spectra of aircraft noise, we note the following pertaining to special audible characteristics of engine testing noise.

- **Impulsiveness:** Engine testing noise is not impulsive by nature and does not warrant any corrections for special audible characteristics.
- **Tonality:** With reference to the monitoring data, collated with published data, we note that the frequency distributions of engine testing noise do not display tonal characteristics as defined above. As such, no tonality adjustments are warranted.

8.8 LA_{max}

The LA_{max} descriptor is not well suited to assess engine testing noise, as the character of the noise is consistent for a long duration with no impulsive noise sources.

When noise is generally steady or fluctuating with no impulses, LA_{max} tends to be close to LA_{eq} (within circa 5dBA). As such LA_{max} would have little relevance in context of amenity from engine testing. We note that for sleep protection, most regulatory standards reference LA_{max} in context of controlling noise emission rather than amenity of indoor noise levels. As described in Section 6.3, the intent is to manage the effects of noise from established activities.

[12] U.S. Federal Aviation Authority - Spectral Classes for FAA's Integrated Noise Model Version 6.0

With the focus of this assessment being amenity from existing noise levels, and in the absence of impulsive noise sources associated with engine testing, the LA_{max} noise descriptor is disregarded.

- Noise from engine testing is not impulsive, and LAmax levels are usually within 5dBA of highest Leq levels.
- LA_{max} is used in a regulatory context for control of noise sources rather than designation of required amenity levels.
- With the focus of this assessment being amenity from existing noise levels, the **LAmax noise descriptor is disregarded.**

8.9 Margin of Error

The assessment in this report depends on modelling of noise propagation from a noise source equivalent to the highest representative noise levels measured during the monitoring periods. For verification of the noise propagation model comparison is made between noise levels predicted and actually measured at the monitoring locations.

We recommend that a margin of error of ±2dBA between a noise propagation model and measured levels would be acceptable, and where a noise model is within this margin of error, it would be considered appropriate. This is supported by regulatory standards as follows:

In accordance with 1.6.1 of NZS 6805[13] the following applies:

> *"[...] review should be considered if it appears that future operations would result in sound exposures more than 3 dB above the specified contours"*

- **Margin of Error:** For the purposes of verifying noise propagation models, a tolerance between predicted and measured noise levels of ±2dB is considered acceptable.

[13] NZS 6805:1992 – Airport Noise Management and Land Use Planning

9 Representative External Source Noise Levels

9.1 Engine Testing Noise Spectra

As noted previously in this report, the frequency distribution of noise associated with engine testing differs between different engine types and varies at different locations around the engine. For example, jet engines have more low frequency content behind the engine than in-front of it. Nevertheless, two types of engine testing are relevant to the subject site with regards to the frequency distribution of noise (relative to the noise levels generated by each):

- **Jet Engine** noise is biased towards low frequency, distributed around the 63-500Hz.
- **Turbo Props** have similar low frequency biased noise to jet engines, albeit with a higher concentration of noise around the 125Hz frequency.

This assessment pertains to the highest representative noise level during a test. While different engines at different locations generate different spectra, the interest in this assessment is the highest noise levels, not just A-weighted, but representative across the spectra. The following table includes representative frequency distributions of Sound Pressure Levels attenuated over distance from jet engine testing.

Sound Pressure Level (LA_{eq})	L_{eq} @					
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
74 dBA	71 dB	75 dB	74 dB	71 dB	68 dB	68 dB	61 dB
72 dBA	69 dB	73 dB	72 dB	69 dB	66 dB	66 dB	59 dB
70 dBA	67 dB	71 dB	70 dB	67 dB	64 dB	64 dB	57 dB
68 dBA	65 dB	69 dB	68 dB	65 dB	62 dB	62 dB	55 dB

Table 1- Examples of Frequency distributions of engine testing at different sound pressure levels

As per the measured noise levels during monitored periods[14], collated with published data[15], measured jet engine noise tests at the highest representative A-weighted noise level, generate higher frequency specific levels across the spectra than the highest noise levels from measured turbo-prop engine tests.

- **Noise Spectra:** Assessment is made against the frequency distribution of the highest representative noise levels associated with jet engine tests, which results in higher noise levels across the spectra than tests of other engines.

[14] Noise from Aircraft by Malcolm Hunt Associates dated 24/08/2017

[15] U.S. Federal Aviation Authority - Spectral Classes for FAA's Integrated Noise Model Version 6.0

9.2 Engine Testing Sound Power Level

With regards to engine testing noise levels, we referenced the reports prepared by Malcolm Hunt Associates (undertaken for the NZDF in 2017), the Marshall Day Acoustics Noise Monitoring and Analysis report (undertaken for The Neil Group in 2021), and the Tonkin + Taylor report (undertaken for the NZDF in 2021).

For the avoidance of doubt, we only reference these reports in context of the monitoring and modelling results and make no comment on the methodology of any of the assessments.

We collated the data available (including the monitoring results) against FAA published data[16] to establish a representative noise source to create a noise propagation model for engine testing representative of highest levels.

- **Max Power (5 minutes):** Lw 150 dBA
- **Pulling Power (10 minutes):** Lw 142 dBA
- **Point Source Elevation:** 4m
- **Example Frequency Distribution at Pulling Power:**

63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
139dB	143dB	142dB	139dB	136dB	136dB	129dB

[16] U.S. Federal Aviation Authority - Spectral Classes for FAA's Integrated Noise Model Version 6.0

10 Amenity Assessment Methodology – Engine Testing

Human response to environmental noise depends on a number of factors, and in all cases is statistical in nature. Acoustic amenity pertains to establishing noise levels and characteristics considered acceptable for the vast majority of people, based on the noise characteristics of the surrounding noise environment. For example, noise levels considered acceptable in a city centre or in proximity to entertainment areas or transport corridors, would not be considered acceptable in a rural setting. As such, an established understanding of the expectation of noise characteristics of the environment is a main parameter underlying design of acceptable internal and outdoor noise levels.

10.1 Existing Noise Environment

Pertaining to reverse sensitivity, where noise sensitive activities are introduced in proximity to an established noise generating activity, we note the following as per 8.4.8 of NZS 6802:2008 (bold added for emphasis):

> *"An important distinction will often need to be made between existing dwellings and potential future dwellings. For reasons now called 'reverse sensitivity', the concept of people coming to a noise source or nuisance* ***not being entitled to an amenity level*** *as if the noise source did not exist has long been upheld"*

Also, I accordance with C1.3 of NZS 6802:2008, the following applies:

> *"The degree of protection will depend upon the nature of the area under consideration. A residential area in a quiet environment can reasonably expect a higher degree of protection than a residential area in an already noisy environment."*

As per the above, it is our opinion that it is imperative that any new occupants in the vicinity of an established noise generating activity are fully aware, and legally acknowledge the nature of the environment. A commonly used mechanism to ensure this acknowledgement is the use of no-complaints covenants on titles and occupancies proposed in the vicinity of an established noise generating activity. This legal acknowledgment allows for the design and implementation of practicable mitigation measures to create amenity levels commensurate with the noise characteristics of the environment. In the absence of legal acknowledgement, unrealistic expectations of internal amenity levels may not be practicably achievable. As such the following is proposed:

- **No-Complaints Covenants:** All titles and any associated tenancy agreements within the subject site to include a no-complaints covenant for the benefit of the SRNZAF.

10.2 Internal Design Criteria – Engine Testing

In accordance with 8.6.4 of NZS6802, the following is noted:

> *"8.6.4: Where it is necessary to assess environmental noise received within dwellings, […] guideline noise levels are given in AS/NZS 2107:2000."*

We note that the AS/NZS 2107[17] standard is not intended for transient or variable noise such as aircraft noise in-flight. The mitigation of noise from flight activities is already regulated and managed by D.24.6.1 of the AUP-OP.

The objective of the internal design criteria in this assessment is the management and mitigation of the higher levels of continuous noise from engine testing. As such, the guidelines detailed in AS/NZS2107[14] apply and can be adopted as per 8.6.4 of NZS6802.

Having established in the no-complaints covenant that the environment includes higher noise levels than would be assumed in a quiet residential area, it would be reasonable to adopt internal noise guidelines associated with areas exposed to high noise levels from engine testing. The guidelines in AS/NZS 2107 comprise a range of internal noise levels, associated with continuous external noise (e.g. from road traffic.) Considering that noise from engine testing would only occur for a few hours at most, and the highest levels for even shorter periods, we consider it would be reasonable to adopt the upper end the recommended range as the guideline limits for internal noise.

As such, the following internal guideline noise levels are adopted as per the upper end of the ranges in Item 7 in Table 1 of AS/NZS 2107 pertaining to houses in city centres, entertainment districts or near major roads (i.e. in noisy environments.) time (t) is proposed to be 15 minutes to align with external noise level designations:

<u>Internal noise levels</u>

- Living Areas: $LA_{eq(15\ mins)}$ 45dB
- Work Areas: $LA_{eq(15\ mins)}$ 45dB
- Sleeping Areas (night-time) $LA_{eq(15\ mins)}$ 40dB

For reference, we note that when the higher noise levels from engine testing are adequately mitigated during the most sensitive periods, it follows by default that lower external noise levels associated with other activities (e.g. flights) and noise during less sensitive periods would have also been mitigated.

[17] AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors.

10.3 Regulatory framework for amenity recommendations

In accordance with 8.6.9 of NZS6802:2008, the following is noted:

> *"8.6.9 […] Additional rules should apply to new and refurbished residential units to achieve adequate isolation of habitable rooms within such buildings from external noise"*

To enable the provision of regulatory rules pertaining to the proposed plan change, the following is the objective of this assessment:

Objective of the assessment is to establish practicably achievable (and demonstrate with example constructions the achievability of) internal noise levels that provide **amenity commensurate with the subject environment based on external noise levels representative of high noise engine testing** activities.

11 Predicted External Noise Levels

11.1 Noise Propagation Modelling Software

To predict noise propagation at the subject site from the engine testing, an environmental model was constructed for the extension using the CadnaA computer modelling program. The following applies to the modelling software CadnaA:

- CadnaA is an internationally recognised software package designed for the prediction of noise propagation. CadnaA implements numerous national and international standards and guideline.
- The modelling method for noise propagation over distance is based on the international standard ISO 9613: "Acoustics – Attenuation of sound during propagation outdoors" methodology.
- The model allows importing digital ground elevation contours and data to define the topography and data for each of the noise sources, and the locations, geometry and elevations of the noise receivers. The program then calculates the dB levels as the metric for noise at receivers for the purposes of assessment.

11.2 Noise Propagation Modelling Parameters

The following parameters were incorporated into the noise propagation models:

Parameter	Value
Standards	ISO9613
Ground Attenuation	Open Space: G=1 Roads, Pavements, G=0, Other: G=0.5
Atmospherics	Temperature: 20˚C, Rel. Humidity: 70%
Topography	Imported from AUP-GeoMaps
Receiver Heights	Relative AGL – Representative of 4m above ground level

We note the following regarding the modelling parameters:

- **Receiver elevation:** The nominated receiver elevation pertains to upper floor receivers. While it is typical to assess environmental noise at 1.5m above ground level for compliance purposes, the intent of this assessment pertains to protection of amenity at most sensitive locations such as bedrooms, usually located on upper floor in a typical two storey dwelling. As such, noise propagation and associated noise contours from engine testing are modelled at a receiver elevation of 4m representative of 1.5m above the level of an upper floor in a typical dwelling.
- **Topography:** We note the subject site is separate from the Airbase by the culvert of the Ratara stream, where the ground dips between the Airbase and the site. The site itself has a general gradient up from the centre to the southern boundary. We note this is accounted for in the noise propagation models.
- **Shielding:** As a conservative measure, all shielding effects of any existing or proposed buildings are disregarded. We note that future developments may include site planning designs that create perimeter shielding, reducing noise levels within the site (e.g. locating three storey townhouse blocks along the perimeter.) As this stage however, this assessment and its associated recommendations pertain to a plan change, where noise propagation is free field (i.e. future development may or may not create effective shielding, whereby this can be assessed, and external noise levels adjusted accordingly at the appropriate stage)

11.3 Predicted Free Field Noise Levels

The following figures are representative of noise propagation in the vicinity, from a representative noise test at TWY-J. Detailed modelling figures, including aerials and topography contours, are included in Appendix I of this report.

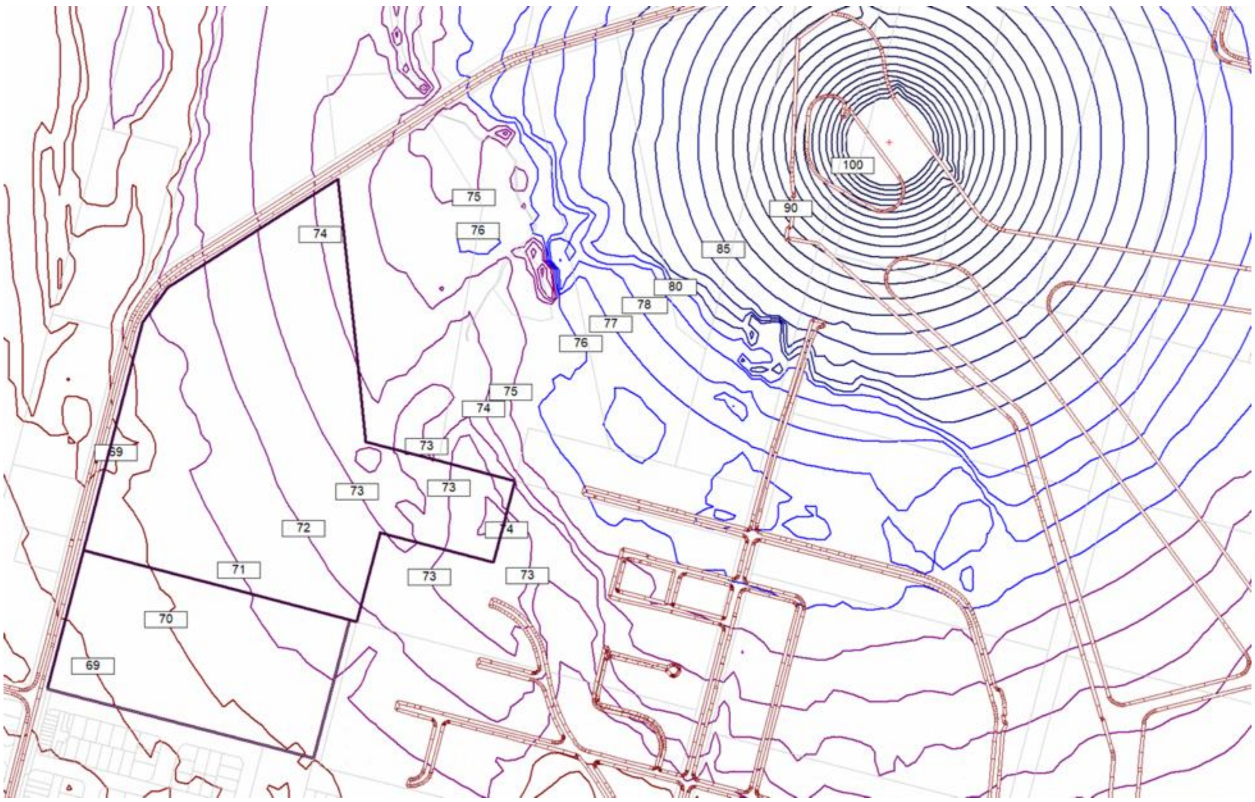

Figure 8 - Noise Propagation Contours - L_{eq} (15 minutes) dBA

As per the above representative noise levels at 4m elevation during engine testing, propagating in free field (i.e. no shielding from buildings or hangars), vary from

- $L_{eq(15min)}$ 74dBA at the northern end of the site, down to
- $L_{eq(15min)}$ 69dBA at the south-western end of the site.

Noise level contours at 7m elevations are included in Appendix I of this report, representative of noise levels at the top floor of three-storey buildings. Due to the distances involved to the noise source, and the assumed 4m elevation of the noise source, noise levels at 7m elevation receivers are less than 1dBA higher than the levels at 4m (rounded up to 1 dBA in the figures.) Considering the difference is within the margin of error of predictions and designs, effects and mitigations that apply at 4m would also apply at 7m.

11.4 Verification of Predicted Noise Levels

11.4.1 Tonkin+Taylor Monitoring

For verification of the model, we note the following:

- Verification is done against the monitoring results at Location 2 designated in the Tonkin + Taylor[18] report - Page 19, F*igure 6.6-Noise Survey Locations.*
- As per the figure below, the predicted noise level at this location at 1.5m is $L_{eq(15min)}$ 83dBA. This would be representative of a max power of 5 minutes at L_{eq} 87dBA and 10 minutes pull power at L_{eq} 77dBA.
- We note the Tonkin + Taylor report does not include $LA_{eq\ (15\ minute)}$ readings, but rather L_{eq} reading which shows the highest levels reached. For comparison, the predicted noise level is deconstructed back to 5 minutes at max power and 10 minutes at pulling power.
- As per the Tonkin + Taylor report – Page 19, *Figure 6.7: Week 1 time history data*, the highest readings (during max power) at Location 2 were circa L_{eq} 87-88 dBA.
- These highest measured levels are within 2dBA of the predicted noise level (based on the 5 minutes of max power averaged over 15 minutes)
- As such, it is reasonable to consider the noise propagation model in-line with measured noise levels and considered valid.

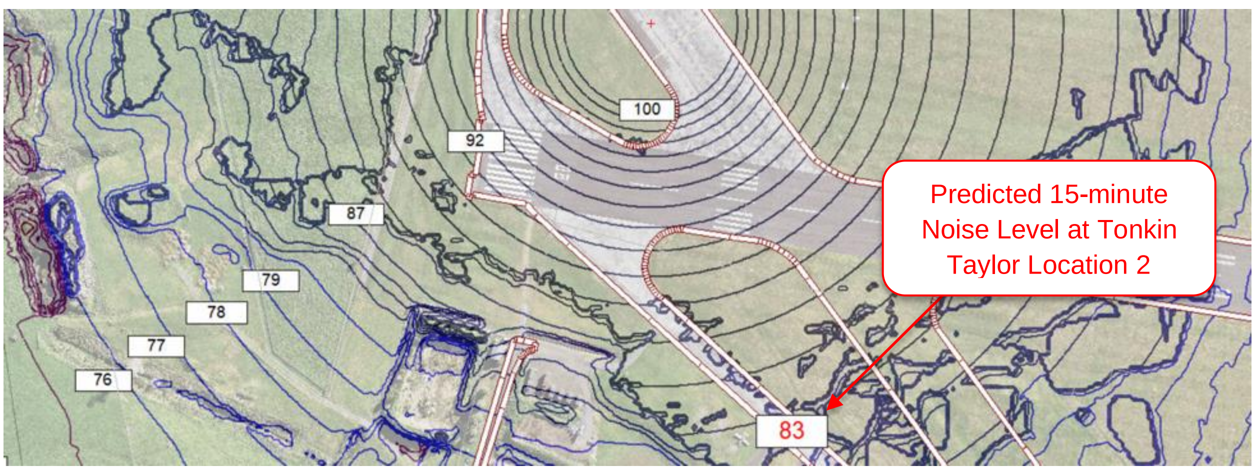

Figure 9 - Predicted Noise Level at Tonkin Taylor Location 2 (at 1.5m elevation)

[18] Engine Testing Noise Contours by Tonkin+Taylor dated 05/03/2021

11.4.2 Marshall Day Acoustics Monitoring

- Verification is also done against the monitoring results of the Marshall Day[19] report, at Location 1 as designated on Page 1, *Figure 1-Site and Monitoring Plan*
- As per the figure below, the predicted noise level at this location is $L_{eq(15min)}$ 84dBA.
- We note the Marshall Day report does not include $LA_{eq\ (15\ minute)}$ readings, but rather $L_{eq(1second)}$ readings for Location 1. For comparison against the monitored noise levels, the predicted noise level is deconstructed back to 5 minutes at max power and 10 minutes at pulling power, whereby the predicted noise level of $L_{eq(15\ minutes)}$ 84dBA would be representative of 5 minutes at L_{eq} 88 dBA and 10 minutes at L_{eq} 78dBA.
- As per the Marshall Day report – Page 13, *Appendix B Sample Graphs of Engine Testing Events – Totara Road*, the highest 1 second readings (during max power) at Location 1 were circa L_{eq} 86-87 dBA (across both graphs for Tuesday 5 May 2020 and Friday 3 July 2020.) The testing periods had general noise levels around circa LAeq 77-80dBA.
- We note the above levels generally correspond to the predicted noise levels at the location where monitoring was undertaken.
- As per the above verification of the predicted noise levels against the Marshall Day monitoring results, it is reasonable to consider the noise propagation model in-line with measured noise levels and as such valid.

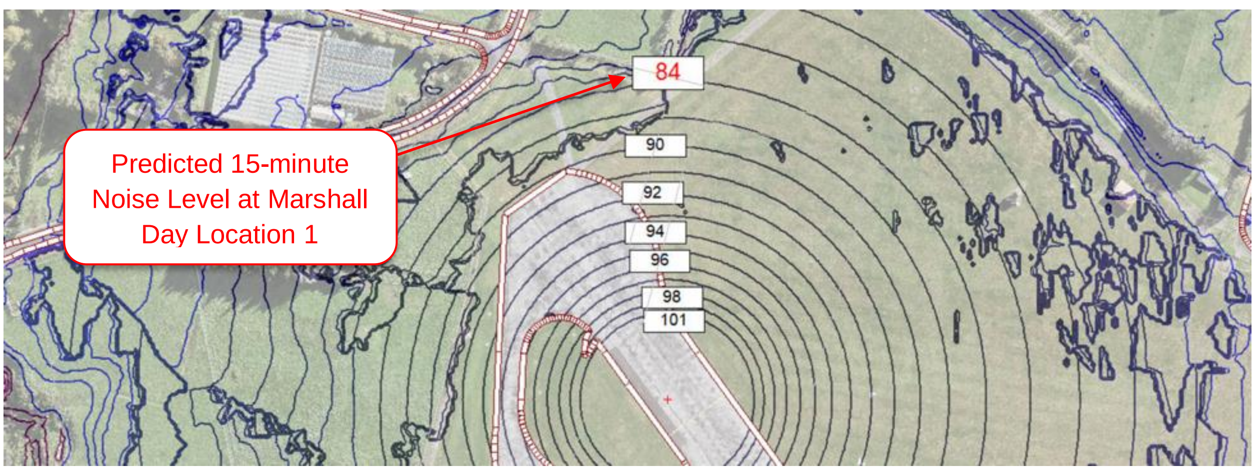

Figure 10 - Predicted Noise Level at Marshall Day Location 1 (at 1.5m elevation)

[19] Engine Testing Noise Logging and Analysis by Marshall Day Acoustics dated 14/04/2021

11.5 Predicted Façade Noise Levels – Representative Orientations

For the purposes of assessing practicable mitigation measures, a noise propagation model was done including a typical two storey dwelling established at the north-eastern end of the subject site where external noise levels are highest. The purpose of this is to consider, in terms of amenity, noise levels on the different facades, and for different elevations. As per the figure below, (shown in more detail in Appendix I) we note the following:

- Two storey buildings (overall height in the order of 6m) create an acoustic shadow effect behind them, reducing noise levels by circa 1-3 dBA.
- Noise levels at the rear facades of a building (facing away from the noise source, are generally 3-4dBA lower than the noise levels at the façade facing the noise.
- Side facades of a building have similar noise levels to the façade facing the noise. We note this is expected considering the distances involved to the noise source.

For the avoidance of doubt, the above does not take into account a number of other parameters associated with buildings, including potential reflections from other buildings (which reduce the shielding effects and increase noise levels.) The above is presented for context of the potential for mitigation options using site planning.

Figure 11 – Shielding effects of buildings (6m height) - $L_{eq\ (15\ mins)}$ dBA

Figure 12 - Noise Levels on representative building facades (6m height) - $L_{eq\ (15\ mins)}$ dBA

12 Recommendations

In accordance with 8.6.9 of NZS6802:2008, the following is noted:

> *"8.6.9 […] Additional rules should apply to new and refurbished residential units to achieve adequate isolation of habitable rooms within such buildings from external noise"*

To enable the proposed plan change, the following is recommended in context of a regulatory framework for potential developments within the subject site:

- For any new building or building alteration containing activities sensitive to noise, the building must be constructed to achieve the following internal noise levels in habitable spaces:
  - Living Areas: $LA_{eq(15\ mins)}$ 45dB
  - Work Areas: $LA_{eq(15\ mins)}$ 45dB
  - Sleeping Areas (night-time) $LA_{eq(15\ mins)}$ 40dB

- The above internal noise limits can be achieved by either:
  - Use of building materials for the building envelope from a schedule of approved constructions based on the external noise levels at the location a building is proposed, Or;
  - Where proposed constructions deviate materially from the approved schedule, the design should be certified by a suitably qualified and experienced person, demonstrating that the construction would comply with the internal noise levels based on the external noise levels at the location a building.

- Building envelope attenuation (whether selected from a schedule or designed by qualified person) would have to be based on external $LA_{eq(15minute)}$ noise contours representative of high noise engine tests, as per the predictive noise model contours detailed in this report.

- Where a development plan comprises a wider sub-division, and the site plans are designed to mitigate noise propagation (e.g. perimeter buildings used as noise barriers), external noise levels used in the design of the building envelope may be adjusted to reflect the attenuation effects of the proposed plan.

We note the above is intended for context only and wording of potential or proposed rules would be a matter for planning teams consider.

13 Mitigation Measures

A number of design considerations can be taken into account to reduce internal and outdoor noise levels, and potentially reduce the acoustic requirements from the building envelope.

13.1 Site Plan

- Minimise gaps between buildings at the eastern and north-eastern perimeter to provide shielding to the buildings behind.
- Prioritise townhouse blocks at the eastern and north-eastern perimeter. Blocks of contiguous townhouses provide more effective shielding to the buildings behind them.
- Upgrade landscape fencing (e.g. overlapping palings) to provide acoustic attenuation to ground floors and provide some amenity in outdoor areas.

13.2 Typologies

- Avoid bedrooms on facades exposed to the highest noise levels.
- Locate bathrooms, and other non-habitable spaces facing east or south, especially at the south-eastern corner of the development.

13.3 Building Envelopes

We note the predicted noise levels from engine testing across the site are typically encountered adjacent high noise routes (e.g. state highways.) Attenuation of noise to the required internal levels can usually be achieved with commonly used and commercially available materials.

The following section is provided to demonstrate how the proposed internal noise levels can be achieved using appropriately selected building envelope materials commensurate with the external noise levels at the location of a proposed building:

14 Noise Effects

Effects of noise are statistical, and all acoustic considerations associated with noise pertain to the vast majority of people, but not to absolutely all people. Response to noise differs between people and may differ for the same person at different times of the day and depends on the surrounding environment and the activity the person is undertaking at the time. The following table is representative of noise levels and the associated human response in context of effect:

Activity/location	Noise Level (LAeq)	Human response
Whispering at 1m	30dB	Calm
Quiet Library	40dB	Peaceful
Moderate Rainfall	50dB	Active
Conversation at 1m	60dB	Beginning of disturbance
Vacuum Cleaner at 2m	70dB	Intrusive, disruptive
Noisy Restaurant	80dB	Loud, conversations difficult
Lawnmower at 2m	90dB	Feeling of heavy noise
Chainsaw at 2m	100dB	Feeling of high noise, beginning of pain
Loud Concert	110dB	Excessive. Bearable only for a short period.

Figure 13 - Human reactions at different noise levels

14.1 Indoor Noise Effects

Human response to noise is highly dependent on the time of day the noise occurs, and what activities are underway when the subject noise occurs. Human response is also dependent on expectations of noise (e.g. living away from noise sources vs close to noise sources.) While this assessment takes a design approach to create the levels of desired amenity commensurate with the environment, the following pertains to the general indoor effects.

14.1.1 Flight Operations

The majority of the subject site is outside the Ldn 55dBA noise contour[20] associated with flight operations. With the proposed mitigation measures to control noise from engine tests, and with windows closed, noise from flight operations would not be noticeable indoors and would not interfere with any activities or sleep, and in many cases would not likely be audible. With windows open during daytime, noise from flight operations may sometimes be "just noticeable" internally above background noise but would not be intrusive or interfere with any indoor activities.

[20] AUP-OP – Infrastructure: Aircraft Noise Overlay – Whenuapai Airbase – Noise Control Area (55dBA)

14.1.2 Engine Testing Events

The adopted internal noise levels are based on the national standards and are inherently designed to provide internal levels of amenity commensurate with the expectations of the soundscape of the area. For reference, the proposed internal design levels are $LA_{eq\ (15\ minutes)}$ 40dB in bedrooms and $LA_{eq\ (15minutes)}$ 45dB in other habitable spaces. For context of the relevance of the 15-minute duration, we note that KiwiRail guidelines for internal noise levels from railway operations pertain to 1-hour time averaging of noise, and NZTA internal noise levels from vehicular traffic pertain to 24-hour time averaging of noise. As such, 15-minute time averaged criteria is considered conservative in context of protection of amenity.

In the daytime, an active living room with a TV turned on, or with people conversing, would have general noise levels in the order of 50-55dBA depending on the level of activity. Noise levels from a normal conversation at 1m are generally at 60dBA.

An external noise source resulting in internal noise at 45dBA would not interfere with indoor activities, conversations, or study, and would generally be masked by other indoor noise sources. This external noise would not be disruptive or intrusive at these levels in general living spaces. We note again that this noise level of 45dBA internally would only occur over a representative worst-case period of 15 minutes. During other periods of an engine testing, noise levels would be in the order of 40-42dBA in living areas when engines are at pulling power, and lower when engines are at low power settings. Internal noise at these levels would not be noticeable in the daytime in a residential setting.

With regards to bedrooms, the main consideration is protection of sleep. The proposed design criteria for internal noise levels applies regardless when engine testing occurs (day or night). This is intended to cater for scenarios where daytime sleep amenity is needed (e.g. shift work, convalescing patients, etc.) During a highest representative 15-minute noise period, internal noise levels in a bedroom may reach up to 40dBA.

The highest noise level of $LA_{eq\ (15minutes)}$ 40dB would generally be described in context of human response as “peaceful”. Taking into account the short duration and characteristics of the noise, this highest noise level would not be cause for sleep disturbance. During other periods of testing (outside the worst-case representative 15 minutes) when pulling power is used, noise levels would be in the order of 35-37dBA and for the remainder of engine testing periods when low power settings are used, internal noise levels would be below 35dBA.

Furthermore, the characteristics of engine testing noise is generally broadband with no particular tonality or impulsiveness. Broadband noise containing energy across the audible frequency range is usually described as white noise or pink noise depending on the bias to low frequency, where pink noise would have a reduction in power at higher frequencies. Examples of pink noise are waves hitting the shore or steady rainfall. Examples of white noise are wind, heavy rain or radio static.

While noise from engine testing externally would generally be characterised as white noise, when assessed internally, it would have characteristics associated with pink noise due to the more effective reduction of noise at the higher frequencies from attenuation through heavy facades. We note here in context of amenity that a 2020 study[21] (published in the United States National Library of Medicine) found that pink noise helped participants fall asleep and achieve deep sleep faster.

As per the above, noise levels associated with engine testing, even at the highest representative 15-minutes, when attenuated to the required internal noise levels, would maintain sleep amenity and may potentially have characteristics aligned with sleep.

14.2 Outdoor Noise Effects

14.2.1 Flight Operations

The majority of the subject site is outside the Ldn 55dBA noise contour[22] associated with flight operations. External noise during flights would be typical of areas at a distance from (albeit not close to) flight paths. Noise from aircraft traversals would increase gradually above background noise as the aircraft approaches a receiver to maximum levels in the order of circa 60dBA then reduce gradually back to background levels as the aircraft traverses away from the receiver. The short duration, level, and relative infrequency of the noise would not preclude or materially impact outdoor activities or amenity.

14.2.2 Engine Testing Events

We note here that several practicable mitigation measures can readily be implemented to lower noise levels in outdoor spaces from engine testing. This includes locating outdoor spaces away from the facades facing the airport, especially along the south-eastern corner of the site. In addition, fencing using acoustically suitable materials would materially reduce noise at ground level where outdoor activities would occur.

Based on these measures, noise levels in outdoor spaces, during the highest worst-case representative 15-minutes, at the areas closest to the airport at the northern end of the subject site would be in the order of $LA_{eq\ (15minutes)}$ 65-70dB.

An external noise level of L_{eq} 65-70dBA may limit some outdoor activities while it is underway, as conversations would require raised voices and the majority of people would only be comfortable

[21] Garcia-Molina G, Kalyan B, Aquino A. Closed-loop Electroencephalogram-based modulated audio to fall and deepen sleep faster. Annu Int Conf IEEE Eng Med Biol Soc. 2020 Jul;2020:565-568. doi: 10.1109/EMBC44109.2020.9175689. PMID: 33018052 - https://pubmed.ncbi.nlm.nih.gov/33018052/

[22] AUP-OP – Infrastructure: Aircraft Noise Overlay – Whenuapai Airbase – Noise Control Area (55dBA)

for periods in the order of an hour. We note the highest noise levels pertain to a 15-minute period which in this context would be tolerable and would not preclude the closest areas to the noise source from outdoor activities. For context, noise levels at an outdoor seating area of a restaurant with music are usually in a higher range of L_{eq} 70-75dBA.

Noise levels during other testing periods at pulling power would be in the order of 60-65dBA and at lower settings would be in the order of circa 50-60dBA at the closest areas to the airport. Noise at these levels would not preclude outdoor activities.

As per the above, taking into account practicable measures pertaining to shielding outdoor spaces from engine testing noise, the effects of engine testing outdoor at the closest receivers to the airport would be tolerable for the durations involved and would not preclude outdoor activities.

15 Example Building Envelope Constructions

This section is intended to demonstrate examples of how building envelope constructions can readily be selected from commercially available materials, in readily buildable configurations, to attenuate external noise levels as predicted across the site to within the proposed internal noise levels.

15.1 Façade Categories

To achieve the proposed amenity levels internally, we would recommend categorising the buildings in areas based on external noise levels.

- Category III: more than 72dB LA_{eq}
- Category II: 68dB - 72dB LA_{eq}
- Category I: Less than 68dB LA_{eq}

The above categories would be based on the noise levels predicted at the location of a building (as per noise contours) during the representative 15-minute period of engine testing.

Where a development plan comprises a wider sub-division, and the site plans are designed to mitigate noise propagation (e.g. perimeter buildings used as noise barriers), external noise levels used in the design of the building envelope may be adjusted to reflect the attenuation effects of the proposed plan.

The following sections detail **examples** of building envelope constructions that can be considered to attenuate noise to within tolerable levels. For the avoidance of doubt, these are **examples only** and not exhaustive or proposed. Alternative configurations and materials are likely to be considered for an approved schedule for future development.

15.2 Façade Walls

15.2.1 Category III

Acoustic performance (sound reduction index):

- R_w 49 for all floors

Example construction:

Element	Wall Materials – Category III Facades
Cladding – Upper Floors	Heavy cladding (e.g. block work, bricks, etc.)
Cladding – Ground Floor	Light-weight cladding (e.g. weatherboard) on RAB pre-cladding,
Lining	Internal Lining of 1x13mm high density plasterboard (e.g. Noiseline)
Frame	140mm Timber Stud
Insulation	R3.2 Insulation (e.g. Pink Batts Ultra R3.2 for 140mm wall)

15.2.2 Category II

Acoustic performance (sound reduction index):

- R_w 49 for upper floors
- R_w 46 for ground Floors

Example construction:

Element	Wall Materials – Category II Facades
Cladding – Upper Floors	Light-weight cladding (e.g. weatherboard) on RAB pre-cladding
Cladding – Ground Floor	Light-weight cladding (e.g. weatherboard)
Lining	Internal Lining of 1x13mm high density plasterboard (e.g. Noiseline)
Frame	140mm Timber Stud
Insulation	Minimum R2 Insulation

15.2.3 Category I

Acoustic performance (sound reduction index):

- **R_w 46 for all floors**

Example construction:

Element	Wall Materials – Category I Facades
Cladding – Upper Floors	Light-weight cladding (e.g. weatherboard)
Cladding – Ground Floor	Light-weight cladding (e.g. weatherboard)
Lining	Internal Lining of 1x13mm plasterboard
Frame	140mm Timber Stud
Insulation	Minimum R2 Insulation

15.3 Glazing

15.3.1 Category III

Element	Glazing – Category III Facades
Glazing / Frame	Glazing with manufacturer attenuation of: **STC/R_w: 38 and PSR (Perceived Sound Reduction): 55%** (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.)
Glazed Area	No more than 25% of external wall area of bedrooms
Glazed Doors	Hinged doors with rubber seals strongly recommended instead of sliding doors. If sliding doors required for balconies, we would recommend balconies are designed as sunrooms (glazed enclosure)
Seals	Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals or high pile brush seals.
Façades	Where a bedroom has two external walls, only one can have glazing, and the relative area of the glazing would be calculated based on the wall with glazing not the total area of multiple walls.

15.3.2 Category II

Element	Glazing – Category II Facades
Glazing / Frame	Glazing with manufacturer attenuation of: **STC/R_w: 38 and PSR (Perceived Sound Reduction): 55%** (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.)
Glazed Area	No more than 35% of external wall area of bedrooms
Glazed Doors	Hinged doors with rubber seals strongly recommended instead of sliding doors. If sliding doors required for balconies, we would recommend balconies are designed as sunrooms (glazed enclosure)
Seals	Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals or high pile brush seals.
Façades	Where a bedroom has two external walls, only one can have glazing, and the relative area of the glazing would be calculated based on the wall with glazing not the total area of multiple walls.

15.3.3 Category I

Element	Glazing – Category I Facades
Glazing / Frame	Glazing with manufacturer attenuation of: **STC 34 / Rw 36** (e.g. 6mm / 12mm AS / 6mm or equivalent.)
Glazed Area	No more than 35% of external wall area of bedrooms
Glazed Doors	Hinged doors with rubber seals strongly recommended instead of sliding doors. If sliding doors required for balconies, we would recommend balconies are designed as sunrooms (glazed enclosure)
Seals	Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals or high pile brush seals.
Façades	If bedrooms have two external walls, then glazing area on each wall can be no more than 20% of the area of each wall.

15.4 Roof

15.4.1 Category III or II

Acoustic performance (sound reduction index):

- **Roofing:** R_w 22
- **Top floor Ceiling:** R_w 34

Example construction:

Element	Roof – Category III or II Facades
Roofing	3mm Asphalt Shingles on 17mm plywood Longrun Steel roofing with plywood underlay
Insulation	Minimum R3.2 insulation
Ceiling Lining	Internal ceiling lining of 1x13mm high density plasterboard (e.g. Noiseline)

15.4.2 Category I

Acoustic performance (sound reduction index):

- **Roofing:** R_w 18
- **Top floor Ceiling:** R_w 34

Example construction:

Element	Roof – Category II Facades
Roofing	Longrun Steel Roofing
Insulation	Minimum R3.2 insulation
Ceiling Lining	Internal ceiling lining of 1x13mm high density plasterboard (e.g. Noiseline)

15.5 Mechanical Ventilation

Mechanical ventilation will be required in all habitable spaces across the subject site to allow windows to be closed and must meet ventilation requirements.

16 Summary

The following is noted regarding the different noise sources from operations at RNZAF Base Whenuapai, in context of both compliance and effects:

- Normal aircraft operations (take-off, landing and taxiing):
  - Compliance: internal noise limit of 40dBA L_{dn} applies as per AUP noise contours.
  - Effects: L_{dn} as a descriptor is well suited for normal flight operations.
- Emergency aircraft operations (take-off, landing and taxiing):
  - Compliance: None required for emergencies.
  - Effects: Disregarded for emergencies.
- Engine Testing
  - Compliance: This is associated with the L_{dn} engine testing noise contours against internal noise levels of 40dBA L_{dn}. Any buildings proposed within the Ldn 57dB contour would likely only need to have mechanical ventilation to comply with the internal noise limit.
  - Effects: L_{dn} is not a sufficient measure to assess amenity or effects from engine testing. Use of external LA_{eq} levels during tests is recommended. A number of mitigation measures should be considered to manage effects.

To enable the proposed plan change, the following is recommended in context of a regulatory framework for protection of amenity of future occupants and protection of the RNZAF Base Whenuapai from reverse sensitivity:

- All titles and any associated tenancy agreements within the subject site to include a no-complaints covenant for the benefit of RNZAF covering all operations.
- Buildings containing activities sensitive to noise must be constructed to achieve the following internal noise levels in habitable spaces:
  - Living Areas: $LA_{eq(15\ mins)}$ 45dB
  - Work Areas: $LA_{eq(15\ mins)}$ 45dB
  - Sleeping Areas (night-time) $LA_{eq(15\ mins)}$ 40dB
- The above internal noise limits can be achieved by either:
  - Use of building materials for the building envelope from a schedule, Or
  - The design should be certified by a suitably qualified and experienced person.
- Building envelope attenuation should be based on external $LA_{eq(15minute)}$ noise contours representative of high noise engine tests.
- Where a development plan comprises a wider sub-division, external noise levels for design purposed may be adjusted to reflect the site plan.

Appendix I – Noise Propagation Models

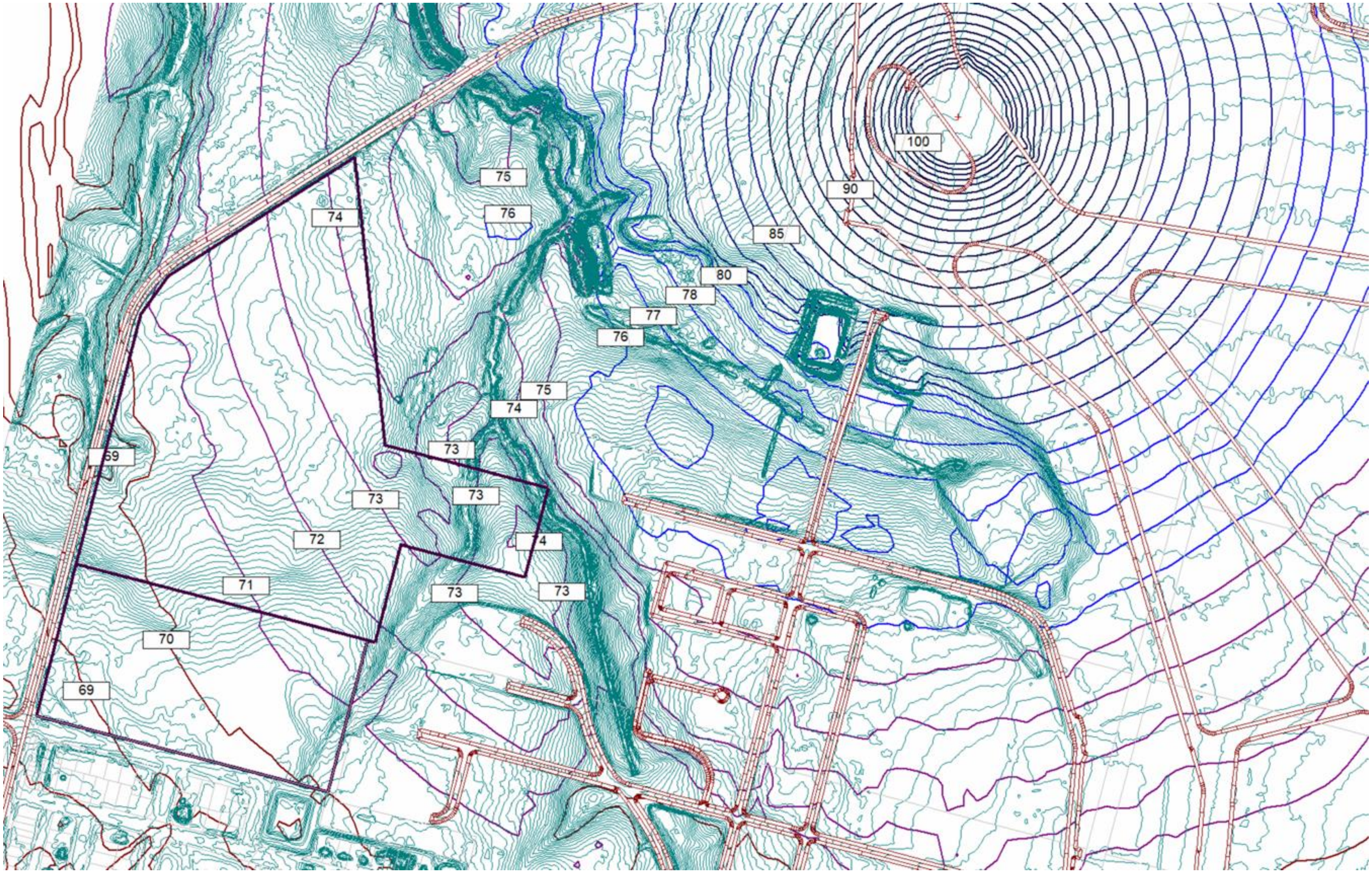

Figure 14 – Free field noise propagation from Engine Testing - Leq (15minutes) dBA- Showing topography contour lines.

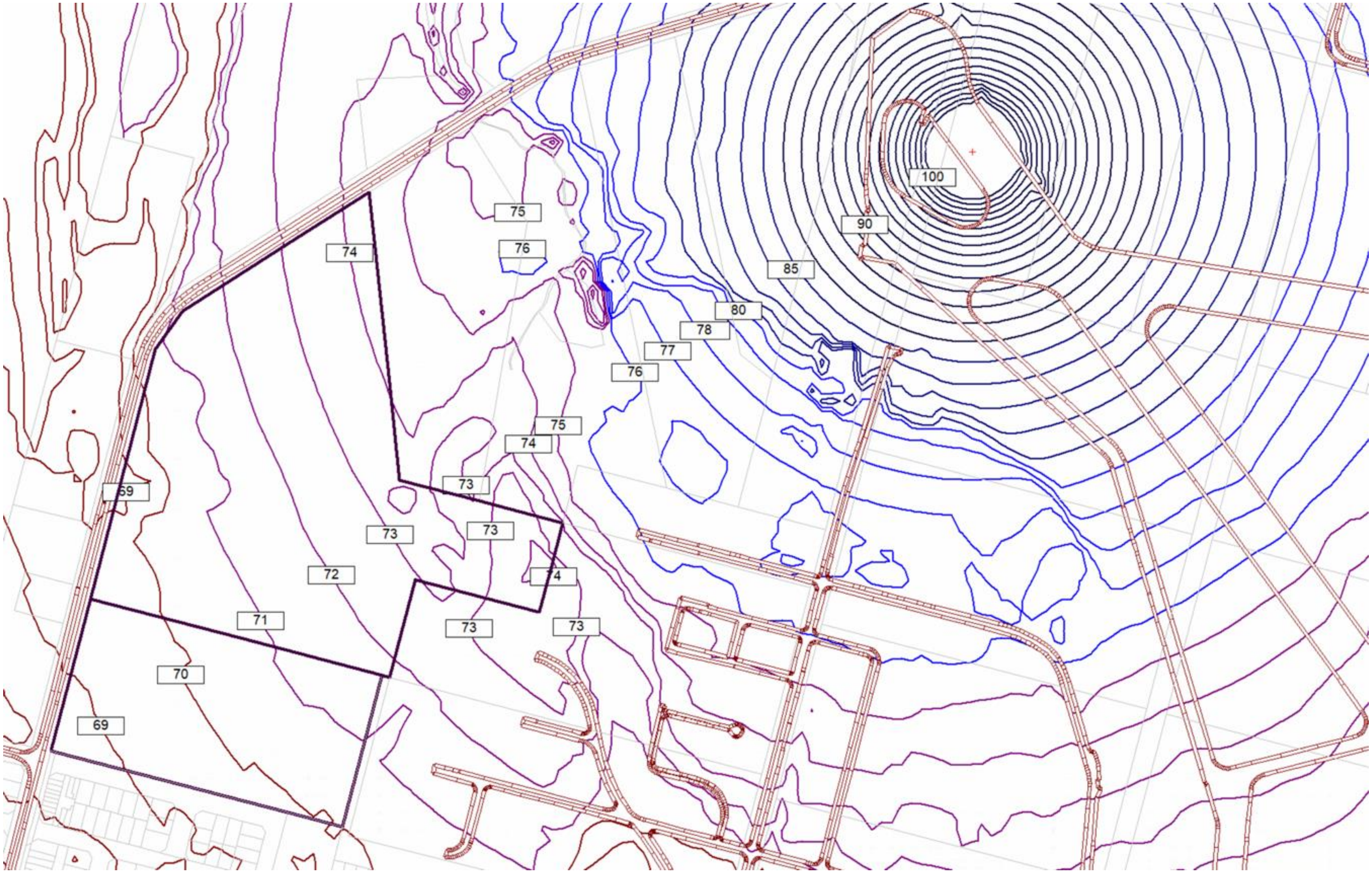

Figure 15 - Noise Contours - Leq (15 minutes) dBA.

Figure 16 – Free field noise Propagation - Contours - With Aerials

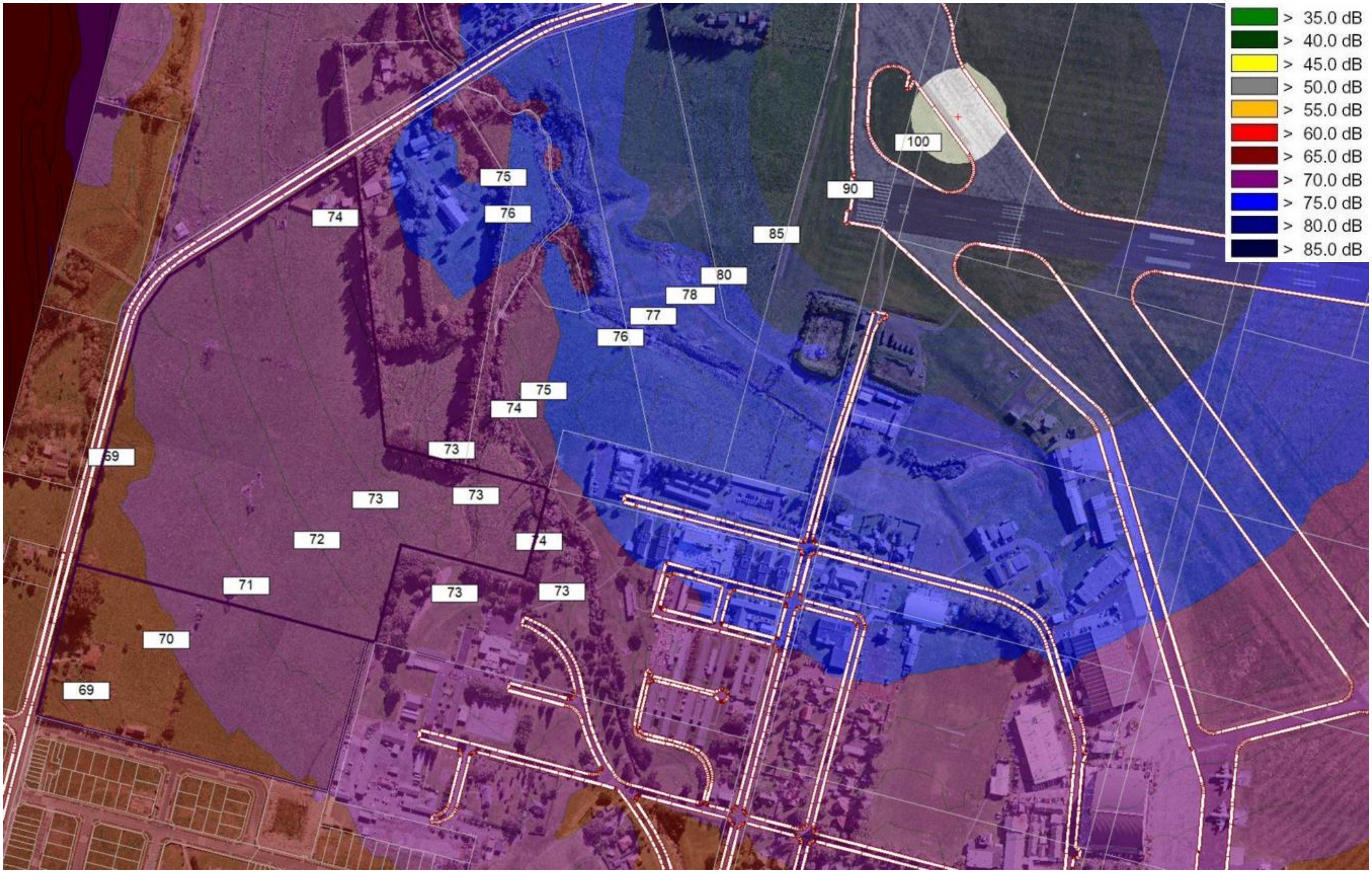

Figure 17 – Free field noise propagation from Engine Testing - Leq (15minutes) dBA- Showing aerials of site.

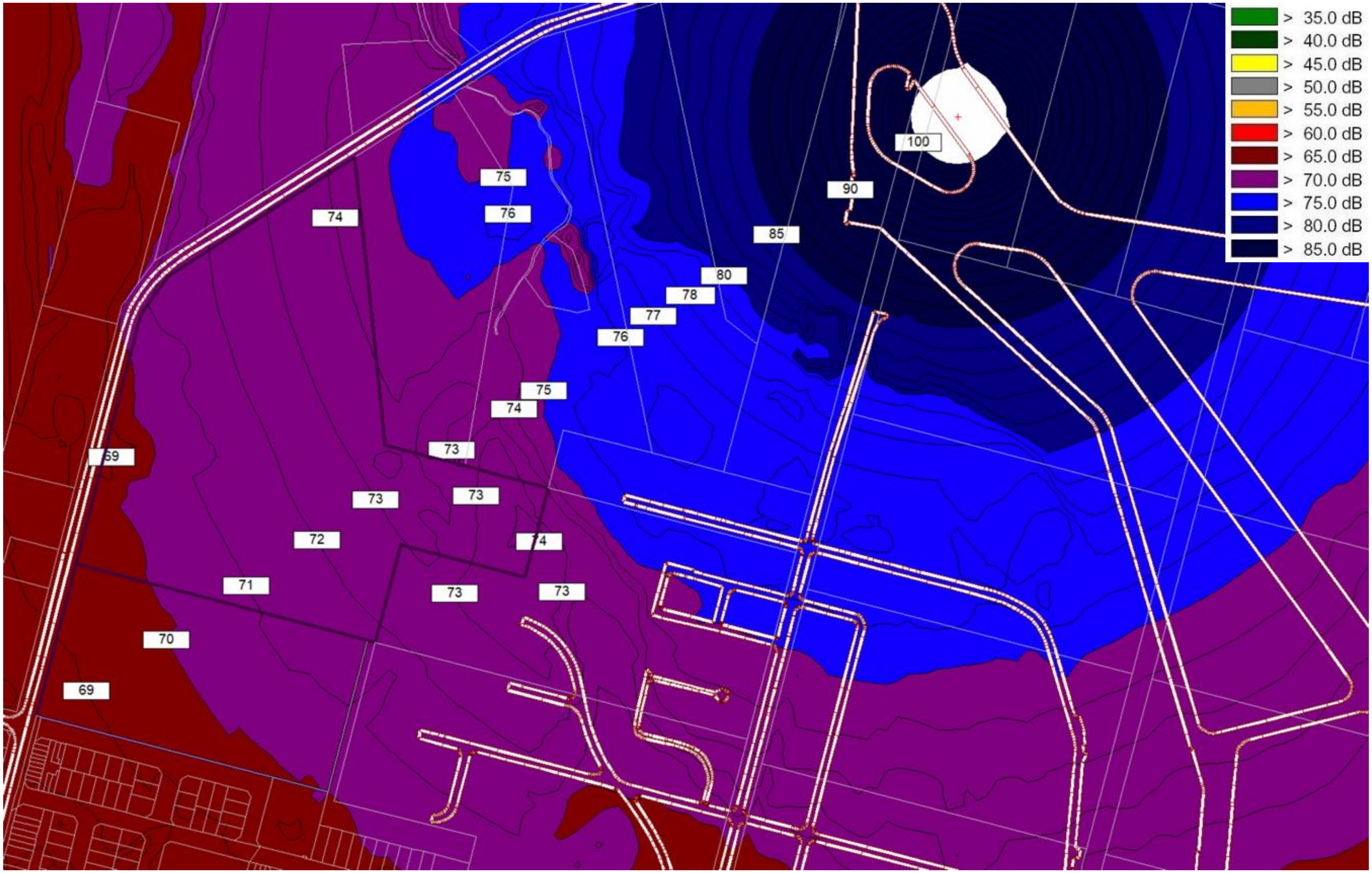

Figure 18 – Free field noise propagation from Engine Testing Areas of Noise- Leq (15minutes) dBA.

Figure 19 - Example 2 storey building - shielding effects.

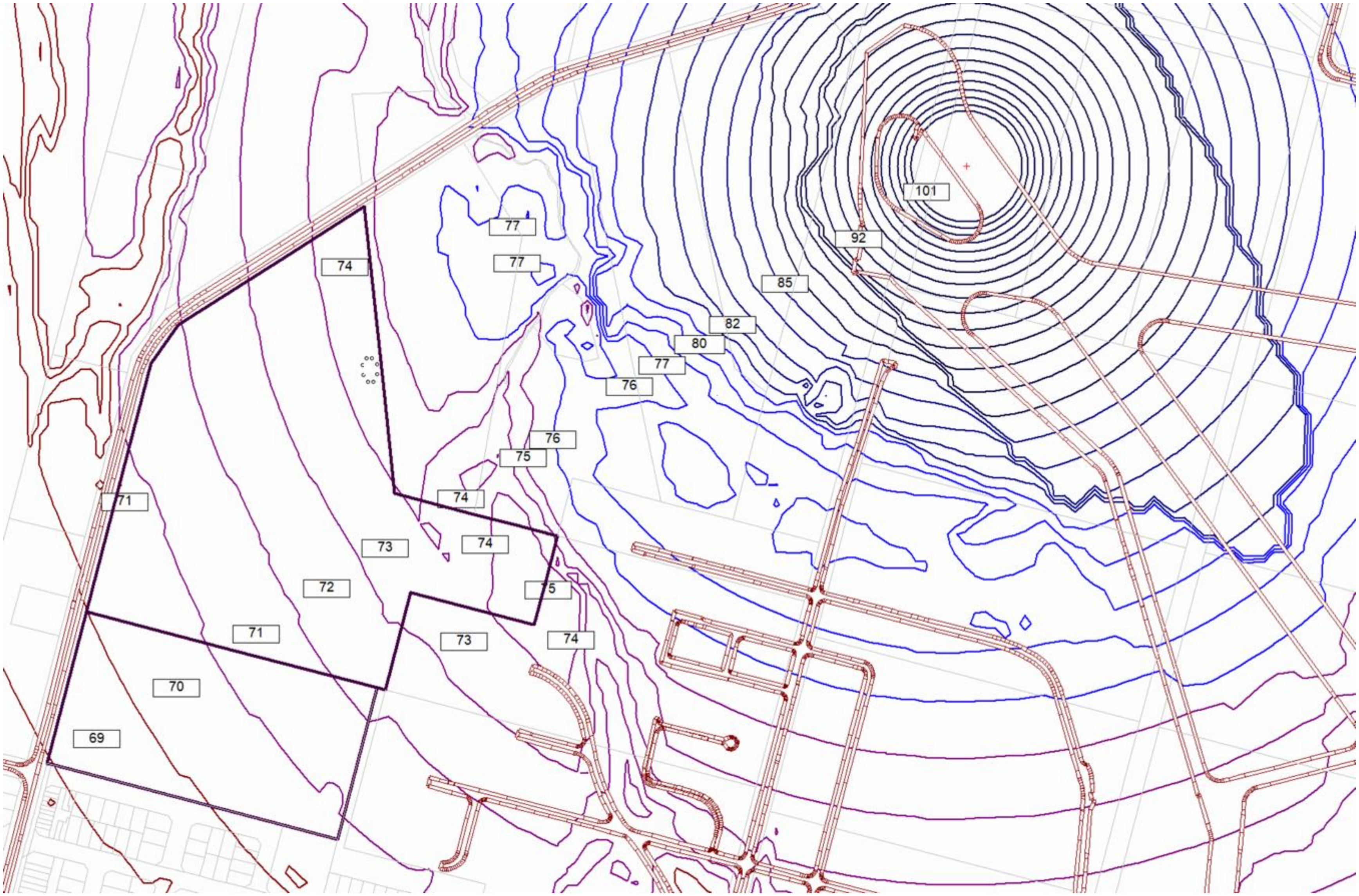

Figure 20 - Noise Contours - Leq (15 minutes) dBA - (Contour at 7m elevation)

Appendix II – RFI Responses – 07/2024

Responses dated 18/07/2024

Query

NV1. Please confirm how emergency flight operations are provided/accounted for in the published AUP noise contours for airbase (i.e., is there an exception noted anywhere or do they form part of the noise contour calculations)?

Response

We are not aware of any published references indicating whether or not emergency flights were included in, or excluded from the AUP day-night noise contour overlay for RNZAF Base Whenuapai. Furthermore, the applicable national standard for Airport Noise Management *NZS6805:1992* makes no reference or differentiation for emergency flights.

One relevant provision in this standard however, indicates that noise contours must be established based on a period of 3 months (Clause 1.4.1.2). It is our opinion that whether or not emergency flights were included in the AUP L_{dn} contours likely depends on whether emergency flights occurred during the period used to establish the contours.

For context, we note that for emergency flight operations of rotary wing aircraft, the following applies as per *NZS6807:1994 – Noise Management and land Use Planning for Helicopter Landing Areas*:

> *C1.1 In general, this Standard is not intended to apply to […] emergency operations such as search and rescue missions (and training for emergencies).*

Query

NV2. The report discusses emergency operation of the airport; however emergency services as defined in the AUP are different to military emergencies as may result in increased use of the airport - what definition of emergency is proposed to make this clear within conditions and covenants etc.

Response

We fully appreciate the point raised here, albeit we generally defer definitions and terminology to the planning and legal teams. Nevertheless, we note that RNZAF operations in context of emergency response, are covered by the definitions of the Civil Defence Emergency Management Act, which we understand applies nationally as would be appropriate for RNZAF operations.

As noted in the query, the RNZAF has roles during emergencies, potentially outside the jurisdiction of the AUP, that cannot be dealt with by emergency services. The following is quoted from the Civil Defence Emergency Management Act:

> ***4. Interpretation***
>
> ***Emergency*** *means a situation that-*
>
> *(a) is the result of any happening, whether natural or otherwise, including, without limitation, any explosion, earthquake, eruption, tsunami, land movement, flood, storm, tornado, cyclone, serious fire, leakage or spillage of any dangerous gas or substance, technological failure, infestation, plague, epidemic, failure of or disruption to an emergency service or a lifeline utility, or actual or imminent attack or warlike act; and*
>
> *(b) causes or may cause loss of life or injury or illness or distress or in any way endangers the safety of the public or property in New Zealand or any part of New Zealand; and*
>
> *(c) cannot be dealt with by emergency services, or otherwise requires a significant and co-ordinated response under this Act*

We note for context that the reference in the assessment to emergency operations is intended to clearly signal in the proposed covenants the possibility that in cases of emergencies, the noise profile of airport operations may change. Human response to environmental noise can be dependent on expectations. As such, the intent of including the potential for emergency flights is to set the expectation that this has the potential to occur.

Query

> *NV3. Related to the proposed no complaints covenants, please confirm details of under what scenario (what operations and limits/levels noting that engine testing contours are not published by AUP) complaints would not be able to be lodged?*

Response

It is our opinion that the no-complaints covenants should provide blanket, unqualified coverage of all RNZAF aircraft and aircraft engine related activities (flight, ground and maintenance). As such, complaints should not be able to be lodged if these pertain to aircraft related activities.

We would not expect covenants to cover non-aircraft related activities (e.g. firing range, amplified sound, etc.) as these would be subject to the applicable AUP standards and complaints would be able to be lodged pertaining to these (if these occur). For context, the intent of the no-complaints covenants is to establish a formal acknowledgement by potential residents that the soundscape of the area includes noise from aircraft related activities of the RNZAF Base Whenuapai. This soundscape forms part of the surrounding environment, and may vary depending on, and to the discretion of, the RNZAF. Regardless whether engine testing contours are published or not, the covenants are formal agreements that the RNZAF are entitled to undertake aircraft related activities without the risk of reverse sensitivity complaints.

Query

> *NV4. Please provide further evidence, such as existing noise level measurements at the subject site, to support the description of the site in Section 10 as a 'high-noise' area, with reference to definitions in Chapter J for High Aircraft noise area and Moderate aircraft noise area if appropriate.*

Response

AUP Chapter J defines the HANA as a "High Aircraft Noise Area" which is a defined term. The reference in in section 10.2 of the assessment is to a "high noise area" from engine testing, not a "High aircraft noise area" pertaining to flights. The assessment clearly differentiates between aircraft flight operations (as is covered by the AUP standards) and engine testing (which is not covered by the AUP standards pertaining to airport operations)The term high noise area is not a defined term and simply refers to an area with high noise from engine testing.

For the avoidance of doubt, the reference is further qualified in Revision C of the assessment as "areas exposed to high noise levels from engine testing".

Query

NV5. Section 11 refers to three-storey dwellings but predicts levels at two-storey dwellings. Please confirm whether modelling based on three-storey dwellings would change the outcome of the assessment. Please provided [sic] updated noise contour figures based on a third level (this will help clearly define when certain treatments would be required as per the proposed precinct approach).

Response

We note that noise level contours at 7m elevations are included in Appendix I of the updated Revision C of the assessment. This is representative of noise levels at the top floor of three-storey buildings. We note that for comparison purposes, noise level markers (numerical values in boxes) are at the same locations as the models for 4m elevations.

Due to the distances involved to the noise source, and the conservatively assumed 4m elevation of the noise source, noise levels at 7m elevation receivers within the site are less than 1dBA higher than the levels at 4m (note shift of contours between the rectangular numerical markers). Considering the difference is within the margin of error of predictions and designs (less than 1dB), effects and mitigations that apply at 4m would also apply at 7m.

Query

NV6. Please update the tables to provide the minimum sound insulation values adopted/required for roof and façade components in Section 14 of the acoustic report (currently only provided for glazing).

Response

These have been included for reference in Revision C of the assessment. We caution here that different materials can achieve similar sound insulation descriptor values (e.g. Rw, STC) despite having different performance characteristics at different frequencies.

Our recommendation is to require an assessment from a suitably qualified and experienced person to demonstrate that an alternative proposed construction would achieve the required internal noise levels.

Query

> *NV7. Could the provisions include the engine testing 15-minute LAeq noise contours and a reference octave band spectrum within the requirements to provide clear expectations on outcomes should applicants not wish to use the acceptable solutions provided? For context this is to assist in ensuring consistent outcomes for applicants who wish to not use the acceptable solutions constructions.*

Response

Spectrums have been added to Section 9.1 of Revision C of the Assessment, and it is our understanding that a reference spectrum has been included in the provisions.

Query

> *NV8. The Proposed Precinct Plan 2 – Noise Mitigation Areas Figure (Appendix D of the application) shows only Category 2 and 3. But the Precinct Provisions refer to Category 1 as well, what is the intention for Category 1? If this approach is to be used it would be clearer if the Categories were defined based on external noise levels as set out in the acoustic assessment. This is also important given I1.6.4 (2) (a) (i) refers to a 3 dB reduction for facades shielded from the noise source – but there are no provided reference levels to apply this 3 dB to.*

Response

We fully appreciate the point raised. The reference levels to apply the 3dB reduction to, are the external noise levels noted in the contours. This would only apply for facades shielded from the noise source, as would need to be demonstrated by an applicant based on site plans and existing structures at the time of an application (or an overall site plan).

We note that the context here is that noise from near-ground sources has significantly different propagation dynamics than airborne noise sources. L_{dn} noise contours associated with flights are relatively straightforward to use when defining attenuation requirements in the vicinity of an airport. The noise levels associated with these contours would be unaffected by shielding effects from introduced structures.

In contrast, noise from engine testing is near-ground, creates shielding effects behind the established structures. An example of this is provided in Section 11.5 of the assessment where the acoustic “shadow” of a representative two storey building is shown.

As such, Category II areas have the potential to reduce to become Category I areas/facades away from the noise source.

With regards to the reference levels for the potential reduction, it is our understanding that a noise contour map (noise propagation models) for engine testing (as per Appendix I of the assessment report) will be included in the precinct plan, with the associated category noise levels, whereby if a reduction in external noise levels is warranted, it would be made against the levels in the contour map for a subject location. The following is an example as per Page 53 of the report

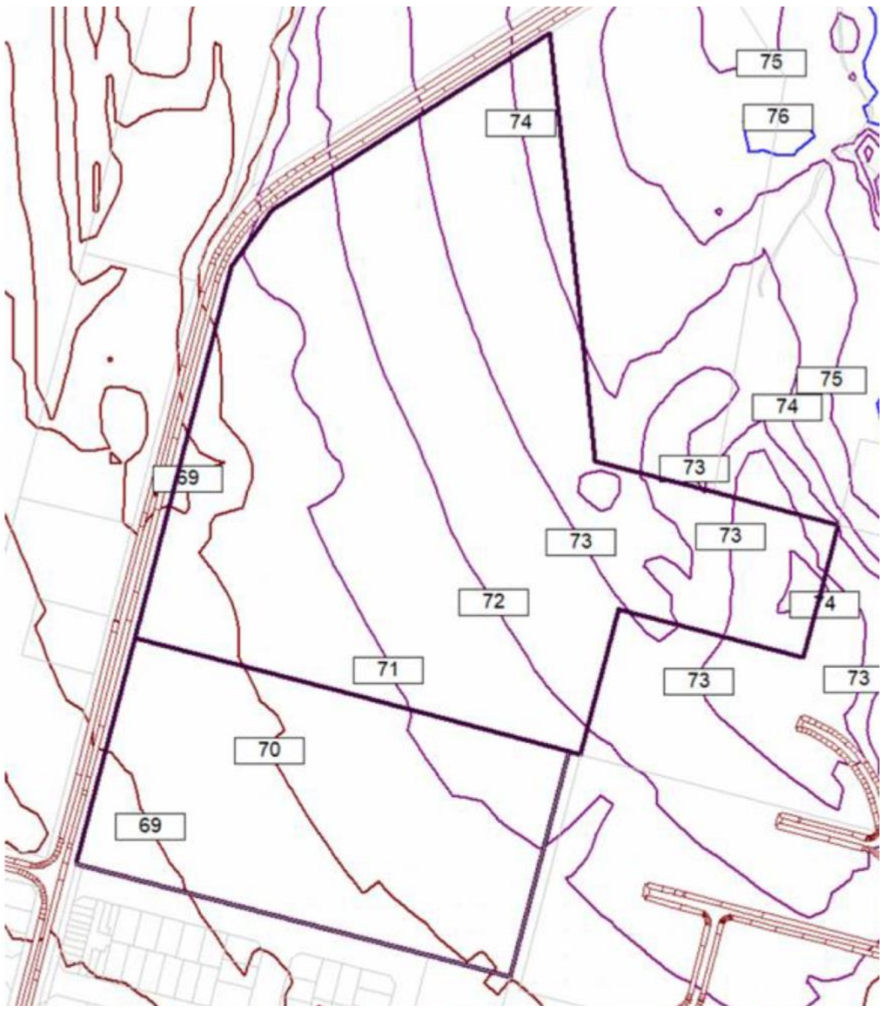

Figure 21 - Noise Contours - Engine Testing

Query

NV9. Category 2 is defined in the acoustic assessment as when engine testing levels are greater than 72 dB LAeq, however the Proposed Precinct Plan 2 – Noise Mitigation Areas Figure (Appendix D of the application) does not match the noise contours in the acoustic assessment. This figure needs to be updated to reflect the acoustic assessment (see screen shots below) – noting these contours may change in response to request [6].

Response

It is our understanding Appendix D of the application has been updated as noted.

Appendix III – RFI Responses – 10/2024

Responses dated 21/10/2024

Query

NV4. Please provide further evidence, such as existing noise level measurements at the subject site, to support the description of the site in Section 10 as a 'high-noise' area, with reference to definitions in Chapter J for High Aircraft noise area and Moderate aircraft noise area if appropriate.

Comments

The answer to query NV4 (relating to measured existing noise levels) does not provide the information requested. The purpose of this request related to the reliance on a definition of the plan change area as a 'high noise area' in order to arrive at the proposed internal noise levels with reference to an AS/NZS standard (page 32 of the Rev C acoustic assessment). This section still lacks evidence (i.e., measured existing levels) to support the high internal levels proposed (which are derived from a comparison to levels based on areas described as 'houses in city centres, entertainment districts or near major roads'). Please provide evidence to support the proposed high internal noise levels.

Response

Thank you for clarifying the request. We note for reference that the premise of the assessment is that the existing noise sources, including flight operations and engine testing, are considered part of the existing environment. For consideration of what constitutes a noisy environment in context of dwellings, reference is made to the Auckland Unitary Plan – Operative Version, whereby as per Section E25.6.2, E25.6.7 and E25.6.8:

- A typical residential area (e.g. suburban) would have noise levels during daytime of less than 50dB LA_{eq} (typically 40-45dB LA_{eq}), and at night less than 40dB LA_{eq} (typically 30-35dB LA_{eq})
- In contrast, a noisier business local or neighbourhood centre (e.g. close to businesses or main roads) would have daytime noise levels of less than 60dB LA_{eq} (typically 50-55dB LA_{eq}), and at night less than 50dB LA_{eq} (typically 40-45dB LA_{eq}).
- City centres in comparison would have daytime noise levels of less than 65dB LA_{eq} (typically 55-60dB LA_{eq}), and at night less than 55dB LA_{eq} (typically 45-50dB LA_{eq}).

As detailed in the assessment, noise monitoring in the area was undertaken by both Marshall Day Acoustics[23] and by Tonkin+Taylor[24]. We note that we make no comment on these reports other than reference the noise monitoring associated with each.

Results of both monitoring activities indicate that noise levels at the subject site, taking into account all existing noise sources including aircraft activities, would in the absence of engine tests, during periods of daytime be generally around or above 50dB LA_{eq} and during periods of night time generally around or above 40dB LA_{eq}. During engine testing events, averaged over the period of a test which is usually in the order of hours, noise levels would be in the order of more than circa 60dB LA_{eq}.

As such, noise levels, as measured at the subject site, would be representative of an environment noisier than typical suburban areas. Taking into account proximity to the airport and potential for noise from engine testing with durations in the order of hours, noise characteristics are not commensurate with suburban or rural areas.

In context of internal noise levels in dwellings, the standard NZS2107:2016 includes design sound level ranges pertaining to:

- Houses and apartments in inner city areas or entertainment districts or near major roads
- Houses and apartments in suburban areas or near minor roads
- Houses in rural areas with negligible transportation

Taking into account the noise levels noted above being representative of environments noisier than suburban or rural areas, and considering the proximity of the area to an existing airport, the area cannot be reasonably classified as "rural with negligible transportation" or as "suburban".

As such, we believe it is reasonable to designate the area as having the higher noise levels than typical rural or suburban environments and propose adoption of the internal noise levels associated with noisier areas analogous with being near major transportation.

[23] Engine Testing Noise Logging and Analysis by Marshall Day Acoustics dated 14/04/2021: https://environment.govt.nz/assets/what-government-is-doing/fast-track/Totara-Landing/115.23_whenuapai_engine_testing_noise_assessment.pdf

[24] Engine Testing Noise Contours by Tonkin+Taylor dated 05/03/2021 https://environment.govt.nz/assets/what-government-is-doing/fast-track/Totara-Landing/115.30_RFI_Response_Engine_Testing_Noise_Contours_Report-TonkinTaylor.pdf

Query

NV6. Please update the tables to provide the minimum sound insulation values adopted/required for roof and façade components in Section 14 of the acoustic report (currently only provided for glazing).

Comments

The response to NV6 discusses the requirement for "an assessment from a suitably qualified and experienced person to demonstrate that an alternative proposed construction would achieve the required internal noise levels", particularly because a simplified single sound insulation value does not capture the performance across different frequencies. This is agreed.

However, what this identifies is the need for this to be provided in the plan change application for the proposed base constructions – currently this is not the case. Section 15 of the Rev C report notes that the description of example building envelope constructions are "examples only and not exhaustive or proposed", yet they are the proposed schedule in the provisions. The opening of this section also notes that the building envelope constructions "can be considered to attenuate noise to within tolerable levels", it is unclear whether this is the same as achieving the proposed internal noise levels.

Assumed individual sound insulation values for the various components have now been provided which has enabled initial check calculations, these suggest that the identified constructions are not likely to be sufficient to achieve the proposed internal noise levels (perhaps out by a significant 5-10 dB). Please provide calculations demonstrating that the various proposed building elements set out in Appendix 2 – Building Requirements of the proposed provisions can meet the proposed provision internal noise limits.

Response

We fully appreciate the point raised here in context of the example constructions. We note that the report is an independent assessment intended to inform the applicant and planning teams of examples of commonly used constructions that would achieve the required attenuation levels.

We defer decisions pertaining to proposed constructions to the applicant and planning teams. For example, the applicant and planning teams may opt to include additional or alternative construction options assessed independently. As such, all references in the assessment pertain to example constructions which are to the discretion of the applicant and planning teams to disregard, adopt or supplement.

Regarding the reference to tolerable levels in Section 15, we appreciate the point raised, but do note that the opening paragraph of the section states (bold added for emphasis):

> *"This section is intended to demonstrate examples of how building envelope constructions can readily be selected from commercially available materials, in readily buildable configurations, to attenuate external noise levels as predicted across the site* ***to within the proposed internal noise levels****."*

As such, we confirm that the examples provided are designed to achieve the proposed internal noise limits.

Regarding sample calculations, the following is noted:

The highest noise levels incident on façades based on categories are as follows:

- Category 3: 74dB LA_{eq}
- Category 2: 72dB LA_{eq}
- Category 1: 67dB LA_{eq}

Prediction of internal noise levels is done in accordance with EN12354/3 using Insul software, based on attenuation of noise across the 1-Octave frequency range of engine testing noise with the maximum external noise levels on a façade. The software calculates outdoor to indoor transmission in accordance with Standard *EN12354-3: Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 3: Airborne sound insulation against outdoor noise.*

Calculations are done based on a representative furnished upper floor bedroom (this being the most sensitive space) exposed to the highest noise level pertaining to façade category:

- Room reverberation time of 0.3s.
- Bedroom area of $10m^2$ and volume of $27m^3$.
- Façade area of $10m^2$ including glazing areas of $2.5m^2$ for Category 3 facades, and $3.5m^2$ for Category 2 and 1 facades.

Assessment is made against the required internal night time noise level of LA_{eq} 40dB during highest external noise levels. Modelled construction materials are in accordance with Section 15 of the assessment pertaining to each category.

The screenshots in the following pages are from the "Outdoor to Indoor Sound Insulation Calculation" screens of Insul Software. As per the calculated results for a sample bedroom exposed to the maximum noise levels with the largest allowed glazing area, internal noise levels would be at or below the internal noise limit of 40dBA for the selected example construction materials detailed in Section 15 of the assessment.

Category 3 façade bedroom with external noise level of 74 dBA

External Noise Levels

Exterior Sound Pressure Level	63	125	250	500	1k	2k	4k	Overall dBA
External Noise - Catgeory 3 Max	71.0	75.0	74.0	71.0	68.0	68.0	61.0	74.2

Performance of each element (wall, glazing and ceiling/roof):

Wall (75% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Wall — Area: 7.5 m²

-Sound Transmission Loss	-23	-34	-49	-43	-49	-54	-67	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	8.8	8.8	8.8	8.8	8.8	8.8	8.8	

Glazing (25% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Glass — Area: 2.5 m²

-Sound Transmission Loss	-22	-24	-24	-35	-43	-44	-49	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	

Ceiling/Roof

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Ceiling — Area: 10.0 m²

-Sound Transmission Loss	-28	-43	-49	-50	-52	-54	-60	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	

Overall noise levels from noise through all elements of the room

Receiving Room

Volume: 27.0 m3

-10 Log(V)+14	0	0	0	0	0	0	0	
Reverberation Times (secs)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
+10 Log(T)	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	
Room sound level	51	48	45	33	24	22	9	39.1

Calculated Internal noise level from an external noise source at 74dBA would be **39.1dBA**

Category 2 façade bedroom with external noise level of 72 dBA

External Noise Levels

Exterior Sound Pressure Level	63	125	250	500	1k	2k	4k	Overall dBA
External Noise - Catgeory 2 Max	69.0	73.0	72.0	69.0	66.0	66.0	59.0	72.2

Performance of each element (wall, glazing and ceiling/roof):

Wall (65% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Wall — Area: 6.5 m²

-Sound Transmission Loss	-16	-24	-42	-49	-52	-48	-56	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	

Glazing (35% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Glass — Area: 3.5 m²

-Sound Transmission Loss	-22	-24	-24	-35	-43	-44	-49	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	5.4	5.4	5.4	5.4	5.4	5.4	5.4	

Ceiling/Roof

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Ceiling — Area: 10.0 m²

-Sound Transmission Loss	-28	-43	-49	-50	-52	-54	-60	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	

Overall noise levels from noise through all elements of the room

Receiving Room

Volume: 27.0 m3

-10 Log(V)+14	0	0	0	0	0	0	0	
Reverberation Times (secs)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
+10 Log(T)	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	
Room sound level	53	50	45	31	22	22	9	39.4

Calculated Internal noise level from an external noise source at 72dBA would be **39.4dBA**

Category 1 façade bedroom with external noise level of 67 dBA

External Noise Levels

Exterior Sound Pressure Level	63	125	250	500	1k	2k	4k	Overall dBA
External Noise - Category 1 Max	64.0	68.0	67.0	64.0	61.0	61.0	54.0	67.2

Performance of each element (wall, glazing and ceiling/roof):

Wall (65% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Wall   Area: 6.5 m²

-Sound Transmission Loss	-14	-21	-40	-47	-51	-52	-54	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	8.1	8.1	8.1	8.1	8.1	8.1	8.1	

Glazing (35% of façade area)

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Glass   Area: 3.5 m²

-Sound Transmission Loss	-22	-23	-19	-36	-45	-41	-43	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	5.4	5.4	5.4	5.4	5.4	5.4	5.4	

Ceiling/Roof

Element 1 | Element 2 | Element 3 | Element 4 | Element 5

Description: Ceiling   Area: 10.0 m²

-Sound Transmission Loss	-21	-34	-40	-41	-47	-53	-60	
-Facade Shape Level diff.	0	0	0	0	0	0	0	
+10 Log(A)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	

Overall noise levels from noise through all elements of the room

Receiving Room

Volume: 27.0 m3

-10 Log(V)+14	0	0	0	0	0	0	0	
Reverberation Times (secs)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
+10 Log(T)	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	
Room sound level	51	48	45	28	18	18	9	38.2

Calculated Internal noise level from an external noise source at 67dBA would be **38.2 dBA**

Appendix IV – RFI Responses – 11/2024

Responses dated 25/11/2024

Query

NV4.	*Please provide further evidence, such as existing noise level measurements at the subject site, to support the description of the site in Section 10 as a 'high-noise' area, with reference to definitions in Chapter J for High Aircraft noise area and Moderate aircraft noise area if appropriate.*

Comments

NV 4 - The argument for the proposed basis of the higher internal noise limit is weak.

Response

We are slightly perplexed by this thread as it implies a disagreement whether the environment includes high noise or not. We also suspect we have not elaborated sufficiently on the methodology of the assessment and where the internal noise limit fits in and what it applies to.

We would like to note the following for the avoidance of doubt:

- The **Internal noise limits (e.g. $LA_{eq\ 15min}$ 40dB in bedrooms) are <u>not</u> intended as the ambient noise levels** within dwellings throughout the day.
- The internal noise levels are **intended for the design of the building envelope in response to the highest <u>15 minute noise event</u>**, this being a max power engine test.

We reiterate that the requirement to achieve 40dBA is specifically against the 15 minutes involving max power engine testing noise (the worst case scenario in any 15 minutes). We are effectively designing the building to account for the worst 15 minutes in a day, which by extension would result in much lower internal noise levels outside the worst case 15 minutes.

To demonstrate this, consider a day when an engine test occurs for a duration of an hour. Based on buildings designed to attenuate the 15 minutes involving max power to the internal noise levels proposed, the ambient noise within bedrooms would have the following profile:

- **23 hours (no engine tests):** Ambient noise levels internally would be in the order of **30dBA-35dBA** (mainly mechanical ventilation if windows closed).

- **45 minutes (engine testing without max power):** Ambient noise levels internally would be circa **35dBA**
- **15 minutes (engine testing involving max power):** Ambient noise levels internally would be up to **40dBA**

Why did we reference NZS2107:2016? To answer the following questions underlying the assessment:

- What is the most sensitive area at the most sensitive time?
  - Bedrooms, at night, <u>during 15 minutes</u> including a max power engine test.
- In an environment with high external noise (i.e. 15 minutes involving max power), what is the noise level at night in a bedroom that would maintain sleep amenity?
  - NZS2107 indicates this would be 40dBA associated with houses/apartments in areas with high external noise.

Based on the above, we proposed adopting the NZS2107 internal noise levels associated with high noise environments to design the building envelope <u>for the 15 minutes of engine testing involving max power</u>. For these 15 minutes, we do not believe there is reasonable dispute as to whether the environment includes high external noise levels or not. It is a fact, demonstrated by measurements, predictions and observations that during these 15 minutes (against which the internal noise are defined) external noise levels are high. The methodology above was intended as a conservative measure to ensure the highest noise events are addressed notwithstanding the short duration.

For context of precedent, we note other regulations pertaining to reverse sensitivity allow averaging over longer durations than the 15 minutes proposed here (i.e. allow for higher internal noise). For example, Kiwirail internal noise limits are averaged over 1 hour. NZTA reverse sensitivity guidelines are averaged over 24 hours, and require an internal noise limit of 40dB $LA_{eq\,(24hours)}$. These 1 hour and 24 hour limits would allow internal noise to reach significantly higher levels than are proposed here.

Again for emphasis, we reiterate that the design internal levels are for the worst case 15 minute periods against which the building envelope would be designed. For all other periods, the design would result in noise levels that are typical, if not lower than, noise levels in typical quiet urban or suburban settings.

As such, this is NOT a case of "*dwellings shall be designed to achieve 40dB $LA_{eq(15min)}$ in bedrooms*", but rather a case of "*the buildings shall be designed to attenuate external noise at the levels shown in the contours to an internal noise level of 40dB $LA_{eq(15min)}$ in bedrooms*" whereby the contours are the worst case 15 minute periods involving max power engine testing.

Query

> NV6. *Please update the tables to provide the minimum sound insulation values adopted/required for roof and façade components in Section 14 of the acoustic report (currently only provided for glazing).*

Comments

> *The calculations used to arrive at indicative constructions appear to make some incorrect or unsupported assumptions which presents the results as out by over 5 dB – meaning there are reasonable doubts the constructions identified in the Proposed Plan Provisions could meet the proposed internal noise levels.*

Response

While it is not clear which assumptions appear to be unsupported, we note for reference the following are the only building assumptions made in the calculations:

- Bedroom Area: $10m^2$ (by far the most commonly encountered bedroom area)
- Ceiling height: 2.7m (typical of recently built upper floor rooms)
- Façade area $10m^2$: circa 3.5m length x 2.7m height.
- Room reverberation of 0.3s: Typical of a furnished $10m^2$ bedroom, and furthermore, the following screenshot is from Insul software pertaining to guideline reverberation times for design purposes:

Room Type	T (s)
Living room	0.5
Bedroom	0.3
Hotel Guestroom	0.4
Office (acoustic tiles)	0.4
Office (hard ceiling)	0.7
Lecture Theatre	1.0
Convention Hall	1.5

- Glazing area: specified by design as a % limit of the façade area (not an assumption)

We note that none of these assumptions stand out as atypical. The calculations are based on the most commonly encountered bedroom design in typical standalone, duplex, and townhouse dwellings of the scale likely to be prominent across the subject site. We also rechecked the calculations and can reconfirm the results quoted in the previous response.

In that context, while we do note that the attenuation levels have minimal buffer margins, we also note the significant number of conservative assumptions made pertaining to the external noise levels (e.g. noisiest engine types, older planes, 4m elevation of noise, etc.). These include reasonable safety margins in the predicted external noise levels (i.e. the external noise levels are likely to be lower than the predictions). We also note (as per the previous query) that the designs are intended for the 15 minutes of highest noise associated with max power tests. Considering the short duration and already included safety margins in the external noise levels, adding further buffers to the design of the envelope may be unwarranted.

Nevertheless, we do accept that at the current stage, it is not possible to be definitive about building layouts, designs, or orientations, and some assumptions have to made. Assumptions by their very nature can be a matter of opinion.

If the Council are of the opinion that notwithstanding all of the above, the dwellings still need additional design buffers for noise attenuation, then a practical solution to consider would be as follows:

- Upgrade the construction examples, such that each Category adopts the construction of the higher category. (e.g. Category II facades adopt the construction examples currently assigned to Category III)
- Category III façades would then adopt the construction examples detailed in the following pages. This would create an additional circa 5dBA buffer in all categories.

For the avoidance of doubt, it is our opinion that the above upgrading of building envelope examples is unlikely to be warranted here. The assumptions made for the example calculations are reasonable and typical, and furthermore, the external noise levels include material safety margins. As such, while we do not recommend this alternative, we provide it as an option for consideration if deemed necessary.

Category 3 Walls

Acoustic performance (sound reduction index):

- R_w 49 for all floors

Example construction:

Element	Wall Materials – Category 3 Facades
Cladding – Upper Floors	Heavy cladding (e.g. block work, bricks, etc.)
Cladding – Ground Floor	Heavy cladding (e.g. block work, bricks, etc.)
Lining	Internal Lining of 1x13mm high density plasterboard (e.g. Noiseline)
Frame	140mm Timber Stud
Insulation	R3.2 Insulation (e.g. Pink Batts Ultra R3.2 for 140mm wall)

Category 3 Glazing

Element	Glazing – Category 3 Facades
Glazing / Frame	Glazing with manufacturer attenuation of: STC/R_w: 38 and PSR (Perceived Sound Reduction): 55% (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.) AND Either: a) Removable acrylic/polycarbonate secondary sash (e.g. Magnetite), minimum 10mm, separated from glazing by a minimum 60mm airgap, OR b) Secondary sash minimum 6.38mm laminated glass, separated from main glazing by a minimum 60mm airgap.
Glazed Area	No more than 20% of external wall area of bedrooms
Glazed Doors	No glazed doors, other than balconies designed as sunrooms (glazed enclosure)
Seals	Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals or high pile brush seals.

Façades	Where a bedroom has two external walls, only one can have glazing, and the relative area of the glazing would be calculated based on the wall with glazing not the total area of multiple walls.

Category 3 Roof

Acoustic performance (sound reduction index):

- **Roofing:** R_w 22
- **Top floor Ceiling:** R_w 39

Example construction:

Element	Roof with any Category 3 Facades
Roofing	3mm Asphalt Shingles on 17mm plywood Longrun Steel roofing with minimum 17mm plywood underlay
Insulation	Minimum R5 insulation
Ceiling Lining	Internal ceiling lining of 2x13mm high density plasterboard (e.g. Noiseline)

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.