



MARSHALL DAY
Acoustics



GREYTOWN SOLAR FARM
FOR FAR NORTH SOLAR FARMS
ASSESSMENT OF NOISE EFFECTS

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Project: **GREYTOWN SOLAR FARM**

Prepared for: **Far North Solar Farms
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Report No.: **Rp 001 20230481**

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SUMMARY

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm.

The proposed generation only 145 MW solar farm would be located at Bidwills Cutting Road, Greytown on the southern side of the township. The proposed solar farm is in three “blocks”: one large block north of Moroa Road and two smaller blocks south of Moroa Road. The combined area of the blocks is approximately 240 hectares.

The proposed solar farm is in a rural area. The surrounding land is used for rural farming and rural lifestyle purposes. Greytown and the surrounding hinterland is flat – there is no significant ground undulation that would result in any appreciable acoustic screening.

The generation facility would include 39 inverters (mostly in pairs). These would be distributed over the farm. The solar panel arrays would include 6,034 motors.

This assessment has drawn the following conclusions:

- The proposed solar farm would readily comply with the Wairarapa Combined District Plan daytime noise rule of 55 dB L_{A10} . Even in the worst-case “100%” scenario, noise levels would be significantly (at least 16 decibels) below the daytime noise rule.
- Evening operation of the proposed solar farm would readily comply with the Wairarapa Combined District Plan nighttime noise rule of 45 dB L_{A10} . Even in the worst-case “100%” scenario, noise levels would be significantly (at least 6 decibels) below the noise rule.
- The proposed solar farm would also comply with the noise rules in the Draft Wairarapa Combined District Plan.
- For dwellings near State Highway 2 and Bidwills Cutting Road, solar farm generated noise levels are expected to be quieter than the existing ambient (L_{A10}) and background (L_{A90}) noise (during the typical hours of solar generation). Solar farm noise levels at dwellings near SH2 would be in the order of 24 to 34 dB L_{A10} , whereas State Highway traffic would generate background and ambient noise levels that are typically higher than this during daylight hours.
- Solar farm noise levels at dwellings on Moroa Road, Settlement Road and Battersea Road would be in the order of 27 to 39 dB L_{A10} at times of solar generation. As the Moroa, Settlement and Battersea Road area is further removed from State Highway 2, it is subject to generally lower noise levels (noting that background noise levels in this area vary depending on local activity). Noise from the solar farm generation is expected to be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area on settled weather days, the solar farm would be audible at times as a low-level constant noise source.
- The NZS 6803:1999 construction noise guidelines will be complied with at all times. This is likely to require noise mitigation to Vermeer-type or any other drop hammer piling works, such as shrouds, dollies or use of alternative methods at piling locations that are within 100 metres of dwellings. A noise management plan is recommended.

Overall the location of the solar farm is well chosen from a noise perspective. The fairly large distances between the sources of noise and the nearest receivers would result in noise from the solar farm being fairly low overall and well below the District Plan noise limits.

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1.0 INTRODUCTION

Marshall Day Acoustics has been engaged by Far North Solar Farms to undertake a noise assessment for the operation and construction of a proposed solar farm.

This report addresses noise from the proposed operation and from construction. This report is intended to form part of an application for resource consent.

A glossary of terminology is included in Appendix A.

2.0 APPLICATION SITE

The proposed generation only 145 MW solar farm is located at Bidwills Cutting Road, Greytown. The site is comprised of three “blocks”: one large block north of Moroa Road and two smaller blocks south of Moroa Road. The combined area of the blocks is approximately 240 hectares and is located on the southern side of Greytown.

The proposed solar farm is in a rural area. The surrounding land is used for rural farming and rural lifestyle purposes. Greytown and the surrounding hinterland is flat – there is no significant ground undulation that would result in any appreciable acoustic screening.

The proposed solar farm is fairly well removed from the nearest rural dwelling receivers. The nearest inverter pair is around 350 metres from the nearest dwelling, though most inverters are around 500 metres or more distant.

Surrounding receivers are listed in Table 1 and depicted in Figure 1.

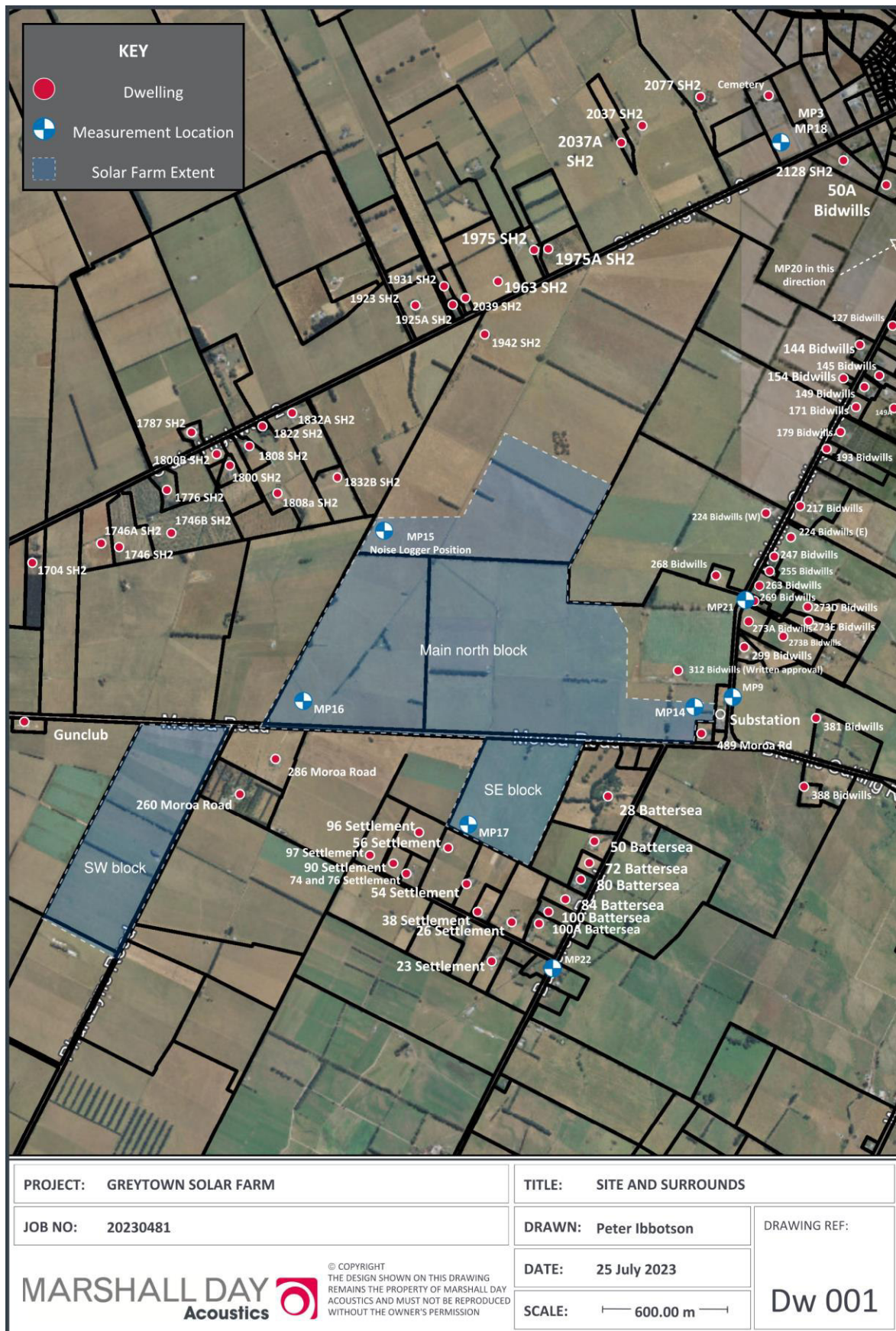
Table 1: Surrounding Receivers

Receiver Location	Details	Typical Use ¹	Approx distance of closest dwelling notional boundary (m) ¹	
			To solar farm boundary	To nearest inverter
Settlement and Battersea Road dwellings	The area to the south and south-east of the south-east solar farm “block” includes several dwellings on 1-to-12-hectare sections	Rural lifestyle	100m	370m
Moroea Road dwellings (west)	There are few dwellings on Moroea Road. There are two larger allotments adjacent to the southwest solar farm “block”. One of these allotments is understood to have worker accommodation on the site in several detached buildings across the site	Rural	Adjacent	350m
Moroea Road dwelling (east)	A dwelling is located to the south-east of the solar farm site, adjacent to the existing substation	Rural lifestyle	Adjacent	480m
Bidwills Cutting Road dwellings	There are many dwellings along Bidwills Cutting Road, though these are typically well removed from the proposed solar farm site.	Rural and Rural Lifestyle	250m ⁽²⁾	600m ⁽²⁾
State Highway 2	There are many dwellings along SH2, though these are typically well removed from the proposed solar farm site. The closest dwelling is some 300m from the solar farm boundary	Rural and Rural lifestyle	50m	550m

Note 1: Existing land use and distances have predominantly been determined from aerial photography and are indicative. The noise model uses specific distances between source and receiver.

Note 2: Excluding 312 Bidwills Road which is the farm owner from whom the land will be leased

Figure 1: Site and Surrounds



3.0 PROPOSAL

We understand that most of the approx. 240-hectare (total) site would be used for the solar farm arrays. The proposed farm location in relation to the surrounding area is given in Figure 1. A site layout plan is given in Appendix B.

The proposed farm would be divided into three blocks, the majority of which would be located to the north of Moroa Road. In this assessment, these blocks are referred to as follows:

- **Main north block:** the largest block (c. 170 Ha), to the north of Moroa Road and west of Bidwills Cutting Rd
- **South-east block:** the block (c. 25 Ha) nearest Battersea and Settlement Roads, south of Moroa Rd.
- **South-west block:** the block (c. 45 Ha) to the south-west of Moroa Road, towards SH2

3.1 Facility Description

Solar panels would be installed in rows spaced apart to allow access by agricultural machinery and grazing animals. Access to the site would be off Moroa Road.

An existing substation is located to the east of the main north solar farm block. A switchyard is proposed to be located adjacent to the substation which will switch the generated power as required to the substation.

The total generation power rating of the farm would be around 135 MW¹.

The key operational noise sources would be from the following plant:

- **39 central inverters.** An inverter turns Direct Current (DC) created by the photovoltaic cells to alternating current (AC) current used in the electricity grid². These central inverters would be distributed throughout the farm and would be used in the generation of power from the solar arrays. The inverters would generally be arranged in pairs of two as shown in Appendix B.
- **Around 6,034 tracker motors** would be associated with the solar panel arrays. Each solar panel array table would be attached to a tracker motor³.
- **A switchyard adjacent to the existing substation.** We understand that two 33/100kV transformers will be located in this switchyard.

Power generation at the solar farm would occur during daylight/sunshine hours. In summer, operating daylight hours could begin earlier and extend later than the prescribed⁴ daytime period of 7am to 7pm. In particular, generation is still likely to be appreciable after 7pm during the longer days of summer. We have allowed for full load on the inverters when solar load is high.

¹ This is the alternating current generation power. The power of each inverter is nominally 4,200 kVA.

² No specific inverter supplier has been selected at this stage of the project. There are two major manufacturers of inverters that are used on most solar projects, although other manufacturers may be considered.

³ Trackers consist of many solar panels on a frame that tilts vertically to align the panels to the sun throughout the day. The trackers are rotated around a central horizontal axis by a small DC motor (approximately 300 watts running at 24V DC). The motor is the main noise source associated with each tracker. The tracker motors are understood to operate intermittently during daylight hours and only for a short period as they are only required to make small incremental adjustments to the trackers. DC motors are quiet, even under continuous load and operation, and the collective sound power level of even a large number of tracker motors is not normally significant when considered over the normally large solar farm sites.

⁴ Refer to Section 5 for discussion of the District Plan noise rules and statutory timeframes.

3.2 Written Approvals

The owner of 312 Bidwills Cutting Road is the lessor of the land that the solar farm would be constructed on. Written approval is understood to have been obtained from this party. The noise effects on this property can be disregarded⁵.

3.3 Acoustic Mitigation

Some inverter manufacturers have shrouds / lined bends that can be provided to the inverter intake and discharge ventilation openings. These result in around 3 to 5 decibels of attenuation per source.

As shown later in this report, acoustic mitigation such as enclosure or attenuation of the inverters is not considered necessary on this project to meet the relevant noise limits or to provide a reasonable level of acoustic amenity based on the inverters expected to be used. The final determination of inverter selection can inform if any further noise mitigation package is required. We would not expect it to be required for most inverter units we have reviewed.

4.0 EXISTING NOISE ENVIRONMENT

Site visits were carried out to measure noise in the area over a period of two days of attended measurements and to deploy a noise logger over a longer period. Noise measurements were conducted at various locations on the site and in the adjacent area as follows:

- The attended noise measurements were carried out at intervals over the period 18:00 hrs 16 July to 17:40 hrs on 17 July 2023.
- A site visit to install a noise logger was carried out on the morning of 22 July 2023. The logger data used in this analysis comprises the period 11:45 hrs, 22 July to 06:00 hrs, 31 July 2023.

The purpose of the measurements was to establish ambient noise levels representative of the site and surrounding sites. The area was observed to have a background and ambient noise character that was typically dominated by human-made noises over the daytime, such as traffic on the state highway and local roads. Natural noises such as bird calls were audible at times. There was little insect noise audible generally during the period of winter monitoring, although insect noise may be more present over the warmer months.

Attended and unattended noise measurements results are summarised in the following sections.

⁵ Council must not, when considering the application, have regard to any effect on a person who has given their written approval to the application (Section 104 (3) of the Resource Management Act 1991).

4.1 Logger Data

The logger measurement position was located at the north-west corner of the site (MP15, refer Figure 1). This location was approximately 760 metres south-east of State Highway 2.

The logger results obtained provides an indication of the variation in traffic noise over the day, evening and night periods at the logger location. Dwellings adjacent to the State Highway will receive higher levels of traffic noise, and dwellings further from the State Highway (e.g., Moroa, Battersea, Settlement Roads) will receive lower levels of traffic noise. However, all will receive a similar *diurnal variation* in noise from distant state highway traffic⁶.

As the solar farm may operate outside the prescribed daytime period, logged data has been analysed for the prescribed daytime, evening and night-time periods⁷.

Refer to Appendix C for the noise level variation over the logging period. Meteorological conditions referenced on this graph were those measured at a NIWA weather station in Masterton and confirmed with the landowner's observations.

The following table summarises noise levels at the logger position.

Table 2: Measured Ambient Noise Levels (logged)

Date	Overall Measured Level (dB) ¹						Likely meteorological conditions
	Daytime hours ²		Evening hours		Night hours		
	L _{A10}	L _{A90}	L _{A10}	L _{A90}	L _{A10}	L _{A90}	
22-Jul	49	44	43	35	37	28	Potentially day winds > 5m/s
23-Jul	46	39	38	28	38	28	Lighter winds, generally < 5m/s
24-Jul	49	45	38	38	42	34	Potentially day/night winds > 5m/s, rain
25-Jul	44	38	43	35	49	40	Light daytime winds, night winds >5m/s
26-Jul	53	43	45	35	42	30	Potentially day winds > 5m/s, rain, light wind night
27-Jul	49	40	45	34	52	45	Potentially day/night winds > 5m/s, some rain
28-Jul	46	39	45	35	39	26	Light winds, no rain
29-Jul	43	38	46	40	39	28	Light winds, no rain
30-Jul	44	37	44	34	39	28	Light winds, no rain

Notes to Table 2:

- (1) An explanation of technical terms is provided in Appendix A
- (2) Daytime is given as 07:00 to 19:00 hours in this table

The logger data shows that average daytime noise levels are relatively high: between 43 - 53 dB L_{A10} even at 760 metres from State Highway 2. Average background noise levels during this time vary from 37 - 45 dB L_{A90} at this distance. Background noise levels are a little lower in lower wind conditions.

⁶ As an approximate guide, dwellings located closer to the State Highway (those around 300 to 400m from the highway) would receive L_{Aeq} and L_{A10} noise levels around 3 decibels higher than those measured at the logger position. Dwellings on Settlement, Battersea and the southern part of Bidwills Crossing Roads will receive noise levels of around 5 decibels lower than measured at the logger position. This is approximate only, and will depend on the meteorological conditions, ground conditions and actual distance between receiver and the State Highway.

⁷ Prescribed daytime hours are: 7am to 7pm. Prescribed night-time hours are: 7pm to 7am.

The logger data shows that noise levels in this area reduce through the evening. This appears to typically occur from around 19:00hrs during weekdays (sunset in July is around 17:00 hrs, so this reduction in noise level currently occurs well after dark). During weekends, the data suggests that ambient noise levels begin to reduce a little later, typically from around 20:30hrs. The reduction in noise level at these times is likely due to reducing traffic on the State Highway.

The average evening ambient noise levels varied from 38 to 46 dB L_{A10} with background noise levels between 28 to 40 dB L_{A90} . Note that the evening period currently occurs in the hours of darkness – it is probable that in the warmer months when days are longer that evening noise levels will be higher (due to birds, insects and potentially different traffic patterns).

The logger data shows that morning ambient noise levels are typically elevated by 05:30 to 06:00 hours on weekdays and around 07:00 hours on weekends.

4.2 Attended Measurements

Attended measurements were carried out on and off site to establish the existing level of environmental noise in the area and to identify the main sources of noise that occur at all surrounding dwellings. Table 3 summarises the attended measurement results.

Table 3: Measured Ambient Noise Levels (attended)

Measurement Position	Measurement		Measured Level (dB) ¹				Noise Source ²
	Date Start (hh:mm)	Duration min:sec	L_{Aeq}	L_{A10}	L_{A90}	L_{AFmax}	
MP3: At cemetery on SH2 (evening), around 65 m from SH2, representative SH2 dwellings	16/07/2023 18:08	15:14	55	59	43	70	Cars are frequent and there are few lulls between vehicles of any significance. During lulls, levels fall away to 45 dB L_{AF} but any lulls are brief and there is always some distant traffic.
MP14: At southern end of proposed Solar Farm (day), near 489 Moroa Rd	17/07/2023 10:39	10:05	48	50	42	63	Traffic on Bidwells Cutting and Moroa Road. Transformer hum at 100Hz. Regular bird calls. Possible distant SH2 noise
MP15: At north-west end of proposed solar farm (day), somewhat representative of SH2 dwellings that are closest to farm (noting measured levels are somewhat lower than dwellings will receive)	17/07/2023 11:18	10:06	37	39	34	50	Distant SH2 traffic, birds (magpies), Possible distant constant noise from industry, but likely distant traffic. Noted absence of insects. Environment noted to consist of predominantly manmade noise
MP16: At south-west corner of proposed solar farm main block (north Moroa Road), representative of Moroa Road dwellings (day)	17/07/2023 11:43	08:01	35	38	31	56	Distant SH2 traffic and magpies. Similar but quieter than MP15



Measurement Position	Measurement		Measured Level (dB) ¹				Noise Source ²
	Date Start (hh:mm)	Duration min:sec	L _{Aeq}	L _{A10}	L _{A90}	L _{AFmax}	
MP17: At south-west end of south-east "block". Representative of dwellings on Settlement Road and Battersea Road (day)	17/07/2023 12:05	10:01	34	36	30	49	Distant traffic on Bidwills Cutting Road. Distant dog barks and cattle lows. Birds. Two vehicle movements on Battersea Road. Background broadly set by distant traffic.
MP18: At cemetery on SH2 (day), representative of SH2 dwellings	17/07/2023 16:13	15:01	56	59	46	69	Traffic on SH2 is regular, birds also audible
MP20: Kemptons Line, near intersection of Bidwills Cutting Road. Representative of dwelling façades on Bidwills Cutting Road	17/07/2023 16:44	10:18	53	56	43	74	Traffic and birds, traffic is regular but some regular gaps in traffic.
MP21: Bidwills Cutting Road near 273 Bidwills Cutting subdivision	17/07/2023 17:02	10:01	72	75	44	88	Frequent traffic on Bidwills Cutting Road (note that measurement location is closer to road carriageway than dwelling façades, therefore raised L _{Aeq} and L _{A10})
MP22: Settlement Road and Battersea Road Intersection	17/07/2023 17:24	10:04	46	49	34	62	Distant traffic, birds, cattle, distant, people noise calling, cars at nearby house. distant loud dog bark, distant train horn. SH2 sets background noise level

Note to Table 3:

- (1) An explanation of technical terms is provided in Appendix A.
 (2) Dominant sources are underlined.

The results show that ambient noise levels depend on the proximity to the State Highway.

Noise levels near State Highway 2 are elevated during the daytime and evening and are up to 59 dB L_{A10} at around 65 metres from the road. As there are few gaps between vehicles on SH2 during the daytime and evening, background noise levels are also elevated at between 43 to 46 dB L_{A90}.

Noise levels at dwellings to the north, west and south of the proposed solar farm (e.g., dwellings on Moroa, Settlement and Battersea Roads) vary with the time of the day and the distance of these dwellings from the busier Bidwills Cutting Road. Measurements conducted around the site during daytime hours in settled conditions show that noise levels for dwellings well removed from Bidwills Cutting Road are around 35 to 40 dB L_{A10} and 30 to 35 dB L_{A90} – although noise levels can be up to 50 dB L_{A10} at times when birds are active and there is activity at nearby dwellings.

Dwellings on Bidwills Cutting Road (at around 60 metres from the road) may receive ambient noise levels of up to 56 dB L_{A10} with background noise levels of 40 to 45 dB L_{A90} due to regular traffic on this road during the daytime.

5.0 NOISE PERFORMANCE STANDARDS AND LEGISLATION

The site is subject to the Operative Wairarapa Combined District Plan noise rules. We understand that a draft Wairarapa Combined District Plan has also been prepared.

5.1 Operative District Plan

5.1.1 Zoning

The application site is situated on land zoned *Rural Primary* Production in the Operative Wairarapa Combined District Plan. Surrounding sites are also zoned *Rural Primary*.

5.1.2 Operative Noise Rules

Section 4.5 of the Wairarapa Combined District Plan sets out the noise rules for the Rural Zone. Rule 4.5.2(f) sets out the noise limits for the zone as follows:

(f) **Noise Limits**

(i) *The sound level from activities within any site, excluding mobile sources associated with primary production (e.g. tractors, harvesters), shall not exceed the following limits within any measurement time interval in the stated time-frames, when assessed at any point within the notional boundary of any dwelling on any site within the Rural Zone but excluding any dwelling on the property where the sound levels are generated, and at any point within the boundary of any site within the Residential Zone:*

Daytime	7:00am to 7:00pm	55 dB L_{A10}
Night-time	7:00pm to 7:00pm	45 dB L_{A10}
	9:00pm to 7:00pm	75 dB L_{AFmax}

(ii) *All sound levels shall be measured in accordance with NZS 6801:1999 “Acoustics – Measurement of Environmental Sound”, and assessed in accordance with NZS 6802:1991 “Assessment of Environmental Sound”.*

The above noise rules are fairly typical of Rural zones throughout New Zealand. However it is noted that the statutory daytime in this District is between 7am to 7pm and the statutory night-time therefore begins somewhat earlier than is typical for many rural zones around New Zealand. As there will be times during summer when there is still strong sunshine after 7pm, this means that the solar farm will need to comply with 45 dB L_{A10} when operating at peak generation.

5.1.3 Construction Noise Rules

The Operative District Plan contains the following noise rule (Rule 21.1.13(c))

(c) **Construction Noise**

(i) *Construction noise shall be measured and assessed in accordance with NZS6803:1999 “Acoustics – Construction Noise” and shall not exceed the noise limits set out in Table 2 of that Standard for the timeframes stated.*

(ii) *Provided that the provisions of the standard related to the duration of construction events and the more or less stringent noise limits applicable in such circumstances shall apply.*

5.2 Draft District Plan

5.2.1 Zoning

In the Draft District Plan, the site is zoned *General Rural Zone*. All adjacent sites would also be zoned *General Rural Zone*. There would be some more distant sites closer to Greytown that would be zoned *General Industrial Zone* and *Mixed Use Zone*.

5.3 Draft Noise Rules

The draft District Plan sets out noise rules in NOISE-R1. This rule requires that activities comply with noise rules NOISE-S1, S2, S3 and S4. Of these, only parts of S1 and S2 are relevant to the proposed solar farm operation. These are given as follows:

NOISE-S1 Maximum Noise Levels in Zones

Rural Zones and Future Urban Zone

3. Noise emitted from any activity within a Rural Zone or Future Urban Zone shall not exceed the following noise limits at any point within the notional boundary of any noise sensitive activity on any other site within a Rural Zone or Future Urban Zone, or at any point within the boundary of any other site within a Residential Zone or Māori Purpose Zone:

- a. Daytime (7.00am to 7.00pm): 55 dB $L_{Aeq(15min)}$;*
- b. Evening: (7.00pm to 10.00pm): 50 dB $L_{Aeq(15min)}$;*
- c. Night time: (10.00pm to 7.00am): 45 dB $L_{Aeq(15min)}$; and*
- d. Night time: (10.00pm to 7.00am): 70 dB L_{Amax} .*

All Zones

All sound levels shall be measured in accordance with NZS 6801:1999 Acoustics Measurement of Environmental Sound and assessed in accordance with NZS 6802:1991 Assessment of Environmental Sound.

NOISE-S2 Maximum noise levels for specified activities

Construction

1. Construction noise shall be measured, assessed, managed, and controlled in accordance with the requirements of New Zealand Standard NZS 6803:1999 Acoustics Construction Noise.

5.4 Discussion of Operative and Draft Rules

We do not expect that the draft rules will yet have statutory effect. Regardless it is noted that the Draft District Plan noise rules are likely to be somewhat less restrictive than the Operative District Plan rules, given that the Draft District Plan introduces an evening shoulder period noise limit that is less restrictive than the Operative District Plan noise rule. Compliance with the Operative District Plan noise rules would also result in compliance with the Draft District Plan noise rules⁸.

Both versions of the Plan require construction noise to be measured and assessed using NZS6803:1999. This is a standard approach in most Districts.

Both the operative and draft District Plans require sound levels to be measured in accordance with NZS 6801 and assessed in accordance with NZS 6802. However, the versions of the standards referenced in both plans are the older 1999/1991 versions, rather than the current 2008 versions. We expect that this is an error in the Draft Plan, as the referenced standards do not accord with the National Planning Standards.

⁸ Note that solar farm noise emissions will be typically at a constant level and thus the L_{Aeq} and L_{A10} noise levels are likely to be quite similar.

We consider the best approach is for the assessment to be carried out using the most recent versions of these standards: while there are some differences between the current and superseded versions, the outcome of using the most updated version will not be materially different to superseded versions. We have retained the use of the L_{A10} parameter as it is the assessment metric used in the Operative District Plan.

5.5 Resource Management Act

Under the provisions of the Resource Management Act (RMA) there is a duty to adopt the best practicable option to ensure that noise (including vibration⁹) from any development does not exceed a reasonable level. Specifically, Sections 16 and 17 reference noise effects as follows.

Section 16 states that "every occupier of land (including any premises and any coastal marine area), and every person carrying out an activity in, on, or under a water body or the coastal marine area, shall adopt the best practicable option to ensure that the emission of noise from that land or water does not exceed a reasonable level".

Section 17(1) states that "every person has a duty to avoid, remedy, or mitigate any adverse effect on the environment arising from an activity carried on by or on behalf of the person, whether or not the activity is in accordance with –

(a) Any of sections 10, 10A, 10B and 20A; or

(b) A national environmental standard, a rule, a resource consent, or a designation".

6.0 OPERATIONAL NOISE LEVELS

6.1 Noise Sources and Modelling Methodology

The main noise sources from the proposed solar farm would be the central generation inverters. Tracker motors also generate noise, but to a lesser degree than unattenuated inverters. Some noise is generated by transformers, although modern transformers typically have a low sound power level.

We have prepared a noise model using SoundPLAN® environmental noise modelling which considers factors such as the terrain, screening by buildings, and ground effect. Calculations have been carried out using ISO 9613-2:1996 "Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation". Noise levels have been calculated under meteorological conditions that are favourable to sound propagation¹⁰ and represent the typical 'worst case' propagation situation¹¹.

The following sound power data has been used in the preparation of this noise model. Data has relied on advice given by the manufacturers or from previous measurements we have carried out. We recommend suppliers confirm that the final equipment selected can operate accordingly.

Solar farm inverters may have tonal characteristics at various frequencies. The assessment of environmental noise effects for resource consent allows for inverters to have some tones and the relevant penalties have been applied¹².

⁹ RMA 1991 Part 1 Section 2 Interpretation: Noise includes vibration

¹⁰ These are set out in ISO9613-2 and represent downwind or temperature inversion conditions.

¹¹ Under most daytime metrological conditions, noise levels will be lower than calculated. This is because when the solar farm is operating at full generation, it will be during periods of high solar gain (typically during the middle part of the day). In general, high solar gain conditions correspond with conditions that are not favourable to sound propagation, as sound will refract upward when air temperatures reduce with increasing altitude (temperature lapse). In temperature lapse conditions, noise levels are expected to be around five decibels lower than calculated for the temperature inversion condition.

¹² Tonality would typically be expected to occur at higher frequencies. Higher frequencies are attenuated with distance due to air and ground absorption, as well as topographical screening. Given the distances involved, tonality may not be audibly present at the

We understand that inverter noise levels will reduce at low loads. A reduction in sound power level of four decibels has been allowed for at 10% inverter power output¹³. Available data shows that tonal character is eliminated at low loads.

Table 4: Sound Power Levels

Noise Source	Sound Power Level dBA re 10 ⁻¹² Watts	Number of Units	Directivity	Operation time
Generation Inverters				
DC / AC inverter 4.2 MVA	93 dB L _{WA} (AC end) 88 dB L _{WA} (DC end)	39	Included	Operation during sunshine hours (therefore within the statutory night period on Sunday)
Tracker modules	74 dB L _{WA} (emission when moving) = 100 dB L _{WA} (total L _w for all trackers across total farm ¹⁴)	6,034	None	68 seconds per 15 minutes – sunshine hours
Transformer	79 dB L _{WA}	2 (in switchyard)	None	Sunshine hours
TOTAL SOURCES		41 + Trackers		

6.2 Noise Level Calculations

Noise levels have been calculated at the notional boundaries of the receivers surrounding the farm.

Inverter units will likely have appreciable directivity. We have allowed for each inverter pair to have the AC end facing in different directions, and broadly as shown on the plans. Other orientations may result in a slight reduction in noise level, although this will depend on the orientation of the air intake on the final units selected.

The calculations have been carried out based on the following assumptions:

- Inverter source heights at around 4 metres above ground. Inverters distributed across the site as shown in the site drawings. Inverter plant has been allowed to operate at 100% load at times.
- Transformers with 3m source height
- Tracker motors below the table rotational axis at 3m above ground level.

Calculations have applied a broad special audible character¹⁵ correction in accordance with NZS 6802:2008. As the solar farm could potentially operate for more than 80% of the prescribed daytime period (particularly during summer), no duration correction has been applied. Furthermore, as the solar farm can generate during part of the statutory night period (after 7pm), no duration correction is possible at that time.

receiver as any tones may be below the background level. Nonetheless we have conservatively allowed for tonality to be potentially present at low levels.

¹³ Our analysis has allowed for inverter ventilation fans to operate at 100% even during times of low power generation. This is likely a conservative assumption where fans are variable speed.

¹⁴ Recent data from manufacturers suggests a sound power level of 74 dB L_{WA} for solar farm 24V DC-type motors at all ranges of torque loads.

¹⁵ Spectral data from some inverter manufacturers shows the potential for tones therefore, a five-decibel special audible character penalty has been applied to the overall noise level from this solar farm. It is possible that tonality will not occur and rating noise levels could be lower – data shows this will occur at lower inverter loads.

6.3 Calculated Noise Levels from Proposed Solar Farm

The following table summarises the results of our calculations. Calculations include a+5 dBA special audible characteristics correction for tonality. No duration correction applied.

Table 5: Calculated Noise levels

Receiver Location	Noise Limits [daytime / night] (dB LA10)	Calculated Rating Noise Level (dB LR)	
		100% LOAD	10% LOAD
Battersea Road, Morison Bush 100	55 / 45	31	27
Battersea Road, Morison Bush 100A	55 / 45	30	26
Battersea Road, Morison Bush 101	55 / 45	28	24
Battersea Road, Morison Bush 28	55 / 45	36	32
Battersea Road, Morison Bush 35	55 / 45	31	27
Battersea Road, Morison Bush 50	55 / 45	34	30
Battersea Road, Morison Bush 72	55 / 45	34	30
Battersea Road, Morison Bush 80	55 / 45	32	28
Battersea Road, Morison Bush 84	55 / 45	32	28
Bidwills Cutting Road, Morison Bush 179	55 / 45	21	17
Bidwills Cutting Road, Morison Bush 193	55 / 45	22	18
Bidwills Cutting Road, Morison Bush 217	55 / 45	25	21
Bidwills Cutting Road, Morison Bush 224 [east]	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 224[west]	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 247	55 / 45	28	24
Bidwills Cutting Road, Morison Bush 255	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 263	55 / 45	30	26
Bidwills Cutting Road, Morison Bush 268	55 / 45	31	27
Bidwills Cutting Road, Morison Bush 269	55 / 45	29	25
Bidwills Cutting Road, Morison Bush 273A	55 / 45	30	26
Bidwills Cutting Road, Morison Bush 273B	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 273D	55 / 45	27	23
Bidwills Cutting Road, Morison Bush 273E	55 / 45	28	24
Bidwills Cutting Road, Morison Bush 299	55 / 45	32	28
Bidwills Cutting Road, Morison Bush 381	55 / 45	26	22
Bidwills Cutting Road, Morison Bush 388	55 / 45	26	22
Moroa Road, Morison Bush 489	55 / 45	36	32
Moroa Road, Tauherenikau 169	55 / 45	28	24
Moroa Road, Tauherenikau 260	55 / 45	38	34
Moroa Road, Tauherenikau 260_1	55 / 45	39	35
Moroa Road, Tauherenikau 260_2	55 / 45	32	28
Moroa Road, Tauherenikau 260_3	55 / 45	31	27
Moroa Road, Tauherenikau 286	55 / 45	33	29
Settlement Road, Morison Bush 23	55 / 45	29	25
Settlement Road, Morison Bush 26	55 / 45	31	27
Settlement Road, Morison Bush 38	55 / 45	29	25
Settlement Road, Morison Bush 45	55 / 45	29	25

Receiver Location	Noise Limits [daytime / night] (dB L _{A10})	Calculated Rating Noise Level (dB L _R)	
		100% LOAD	10% LOAD
Settlement Road, Morison Bush 51	55 / 45	27	23
Settlement Road, Morison Bush 51	55 / 45	27	23
Settlement Road, Morison Bush 53	55 / 45	29	25
Settlement Road, Morison Bush 54	55 / 45	34	30
Settlement Road, Morison Bush 56	55 / 45	38	34
Settlement Road, Morison Bush 73	55 / 45	30	26
Settlement Road, Morison Bush 74	55 / 45	30	26
Settlement Road, Morison Bush 74A	55 / 45	32	28
Settlement Road, Morison Bush 76	55 / 45	32	28
Settlement Road, Morison Bush 90	55 / 45	32	28
Settlement Road, Morison Bush 96	55 / 45	34	30
Settlement Road, Morison Bush 97	55 / 45	33	29
State Highway 2, Tauherenikau 1688	55 / 45	26	22
State Highway 2, Tauherenikau 1690	55 / 45	25	21
State Highway 2, Tauherenikau 1704	55 / 45	26	22
State Highway 2, Tauherenikau 1724	55 / 45	24	20
State Highway 2, Tauherenikau 1746	55 / 45	26	22
State Highway 2, Tauherenikau 1746A	55 / 45	26	22
State Highway 2, Tauherenikau 1746B	55 / 45	27	23
State Highway 2, Tauherenikau 1776	55 / 45	27	23
State Highway 2, Tauherenikau 1776A	55 / 45	26	22
State Highway 2, Tauherenikau 1787	55 / 45	24	20
State Highway 2, Tauherenikau 1800	55 / 45	29	25
State Highway 2, Tauherenikau 1800A	55 / 45	26	22
State Highway 2, Tauherenikau 1800B	55 / 45	27	23
State Highway 2, Tauherenikau 1808	55 / 45	29	25
State Highway 2, Tauherenikau 1808a	55 / 45	32	28
State Highway 2, Tauherenikau 1832A	55 / 45	29	25
State Highway 2, Tauherenikau 1832B	55 / 45	33	29
State Highway 2, Tauherenikau 1923	55 / 45	27	23
State Highway 2, Tauherenikau 1925A	55 / 45	28	24
State Highway 2, Tauherenikau 1931	55 / 45	25	21
State Highway 2, Tauherenikau 1937	55 / 45	27	23
State Highway 2, Tauherenikau 1942	55 / 45	28	24
State Highway 2, Tauherenikau 1963	55 / 45	25	21
State Highway 2, Tauherenikau 1975A	55 / 45	23	19
Bidwills Cutting Road 312 (Written Approval)	55 / 45	40	36
Gunclub: 170 Moroa Road, Tauherenikau	55 / 45	32	28

6.4 Results Summary

Our calculations show that for the compliance receivers that have not given written approval:

- The proposed solar farm would readily comply with the Wairarapa Combined District Plan daytime noise rule of 55 dB L_{A10} . Even in the worst-case “100%” scenario, noise levels would be significantly (at least 16 decibels) below the daytime noise rule.
- Evening operation of the proposed solar farm would readily comply with the Wairarapa Combined District Plan night-time noise rule of 45 dB L_{A10} . Even in the worst-case “100%” scenario, noise levels would be significantly (at least 6 decibels) below the night-time noise rule,
- The proposed solar farm would also comply with the noise rules in the Draft Wairarapa Combined District Plan.
- For dwellings near State Highway 2 and Bidwills Cutting Road, solar farm generated noise levels are expected to be quieter than the existing ambient (L_{A10}) and background (L_{A90}) noise (during the typical hours of solar generation). Solar farm noise levels at dwellings near SH2 would be in the order of 24 to 34 dB L_{A10} , whereas State Highway traffic would generate background and ambient noise levels that are typically higher than this during daylight hours.
- Solar farm noise levels at dwellings on Moroa Road, Settlement Road and Battersea Road would be in the order of 27 to 39 dB L_{A10} at times of solar generation. As the Moroa, Settlement and Battersea Road area is further removed from State Highway 2, it is subject to generally lower noise levels (noting that background noise levels in this area vary depending on local activity). Noise from the solar farm generation is expected to be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area on settled weather days, the solar farm would be audible at times as a low-level constant noise source.

6.5 Operational Traffic

Operational traffic has been assessed for the project. We understand the farm would only require around two staff on site which we expect could generate perhaps 4 to 12 vehicle movements per day. During the initial period of commissioning, we understand that there may be more staff on site and a higher number of traffic movements may result. Operation of the solar farm would only require very occasional heavy vehicle movements, which are not expected to occur during the evening and night periods.

The locations of the vehicle entry points are generally well removed from most dwellings and we therefore expect noise from on-site movements to be very low, typically below the existing background noise level at most dwellings at most times.

Based on our observations, the above number of vehicles would not significantly increase traffic on SH2 or Bidwills Cutting Road. We would not expect traffic noise levels from these roads to appreciably increase. Traffic on Moroa Road may increase markedly over the commissioning period as it currently has few movements per day on it. However the number of overall movements would still remain low. We understand all roads surrounding the proposed solar farm are public roads, and the District Plan rules do not apply to any traffic using these roads.

Overall, we consider that operational traffic noise is likely to be largely insignificant in comparison to existing (non-site) noise traffic noise levels in the area.

7.0 SUMMARY OF OPERATIONAL NOISE EFFECTS

- The location of the solar farm is well chosen from a noise perspective. The significant distances between the sources of noise and the nearest receivers would result in noise from the solar farm being fairly low overall.
- For most dwellings to the north, west and east of the site, noise generated by the solar farm will typically be below the existing ambient and background noise levels. For some dwellings south of the site, solar farm noise may be above the existing background (L_{A90}) noise level at times, but generally similar to or quieter than the existing ambient (L_{A10}) noise level. In this area, the solar farm would be audible on days with settled weather as a low-level constant noise source.
- Compliance with the District Plan noise limits would readily occur for the proposed operation.

8.0 CONSTRUCTION NOISE LEVELS

8.1 On-site construction

Construction of the solar farm is likely to involve the following:

- Delivery of panels, inverters and other infrastructure, requiring trucks and small cranes. Around three trucks per day are expected.
- Earthworks would occur using trucks, loaders and excavators
- A 'Vermeer PD10 Pile Driver' to impact drive the support piles into the ground.

Solar farm construction typically takes place over a period of less than 20-weeks and between the hours 7:30 to 18:00, Monday to Saturday. Therefore, the 'typical duration' construction noise limits: 75 dB L_{Aeq} and 90 dB L_{AFmax} would apply. The proposed Greytown Solar Farm is relatively large, and the total duration of piling could be longer than 20 weeks, however the activity will not be stationary during this time and piling in any one location will occur for much shorter than 20 weeks. Based on section c7.2.1 of NZS 6803:1999, the appropriate NZS 6803 noise limit is 75 dB L_{Aeq} .

All significant equipment likely to be used on the project is listed in Table 6. The sound levels given are based on measurements we have made of similar plant or from BS 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites* Part 1: Noise.

Table 6: Activity Specific Noise Levels at 1m from a building façade (without screening)

Item/Activity	Operating Sound Power Level (dB L_{WA})	Noise Level (dB L_{Aeq})				75dBA Limit Setback (m)
		100m	250m	500m	750m	
Large Trucks (operating within the site)	108	60	50	43	38	25m
Excavators and other earthmoving plant	103	55	45	38	33	14m
Vermeer PD10 Pile Driver (unattenuated impact piling noise level)	123	75	65	58	53	100m
Impact piling (with casing and dolly)	114	66	58	49	44	44m
Concrete truck & pump	103	55	45	38	33	14m
Truck idling	91	43	33	26	21	4m

The majority of dwellings would be well beyond 100 metres from the piling and thus compliance with the District Plan construction noise rules will be complied with at most dwellings. However there are some dwellings that will be closer to the closest piles than this. We have identified these dwellings as:

- Potential worker accommodation on 260 Moroa Road

- 489 Moroa Road
- 56 Settlement Road
- 312 Bidwills Road (written approval from lessor)

The applicant has advised that they will take all required mitigation measures to ensure compliance with the NZS 6803:1999 noise limits at all dwelling façades. In some piling locations close to dwellings, that may mean that unattenuated Vermeer or drop hammer piling may not be able to occur. The applicant would ensure that if a Vermeer-type or drop hammer piling rig was used, that a suitable dolly or shroud (or similarly effective method) is used to mitigate noise from the piling. If the piling contractor advises that that method is impractical for the Vermeer-type rig, the applicant may need to use an alternative method (potentially screw, auger or bored piling) for piles within around 100m of dwellings.

We recommend that a noise management plan is prepared by the piling contractor to show the “zones” where Vermeer-type or drop hammer piling cannot occur. These zones are expected to be relatively small, nonetheless piling in these areas will need to be restricted to attenuated or quieter methods.

The key matter that the noise management plan should show are maps that illustrate the “piling zones” where noise levels may be above the NZS 6803:1999 noise limit without attenuation. Other matters should be addressed in the construction noise management plan as generally required in NZS 6803 and as part of typical best-practice.

There would be no perceptible vibration from the above construction activity.

8.2 Construction vehicles on public roads

Truck and construction passenger vehicle movements will occur on Moroa Road during construction. These are public roads and the construction noise and vibration limits do not technically apply to activities on these roads, although we note that vehicles using these roads would likely generate noise levels that comply with NZS 6803 guidelines regardless.

9.0 RECOMMENDED NOISE CONDITIONS

It is recommended that the following noise conditions are imposed on any consent granted.

1. The noise level from operation of the solar farm shall meet the following noise limits at the notional boundary of dwellings existing at the time of consent on any other site (excluding those where written approval has been obtained):

Daytime	7:00am to 7:00pm	55 dB L _{A10}
Night-time	7:00pm to 7:00pm	45 dB L _{A10}
	9:00pm to 7:00pm	75 dB L _{AFmax}

Noise levels shall be measured and assessed in accordance with NZS 6801:2008 *Acoustics – Measurement of Environmental Sound* and NZS 6802:2008 *Acoustics – Environmental Noise*.

2. Noise from construction activities shall not exceed the typical duration limits recommended in, and shall be measured and assessed in accordance with, New Zealand Standard NZS 6803: 1999 “*Acoustics – Construction Noise*”.
3. A Construction Noise Management Plan (CNMP) shall be prepared and submitted to Council. The CNMP shall identify any areas of piling on maps that are likely to breach the consented construction noise limits without further attenuation. The CNMP shall identify suitable methods of noise attenuation that should be used by the contractor to comply with the noise limits when piling within these zones and/or any procedures that should be carried out to identify these methods of noise attenuation prior to work beginning in these areas.

APPENDIX A GLOSSARY OF TERMINOLOGY

Ambient Noise	Ambient Noise is the all-encompassing noise associated with any given environment and is usually a composite of sounds from many sources near and far.
dB_A	A measurement of sound level which has its frequency characteristics modified by a filter (A-weighted) so as to more closely approximate the frequency bias of the human ear.
L_{eq}	The time averaged sound level (on a logarithmic/energy basis) over the measurement period (normally A-weighted).
L₉₀	The sound level which is equalled or exceeded for 90% of the measurement period. L ₉₀ is an indicator of the mean minimum noise level and is used in New Zealand as the descriptor for background noise (normally A-weighted).
L₁₀	The sound level which is equalled or exceeded for 10% of the measurement period. L ₁₀ is an indicator of the mean maximum noise level and is used in New Zealand as the descriptor for intrusive noise (normally A-weighted).
L_{AFmax}	The maximum sound level recorded during the measurement period (normally A-weighted).
NZS 6801:2008	New Zealand Standard NZS 6801:2008 <i>Acoustics – Measurement of environmental sound</i>
NZS 6802:2008	New Zealand Standard NZS 6802:2008 <i>Acoustics - Environmental Noise</i>
NZS 6803:1999	New Zealand Standard NZS 6803:1999 “ <i>Acoustics – Construction Noise</i> ”
Prescribed time frame	‘Daytime’, night-time’, ‘evening’, or any other relevant period specified in any rule or national environmental standard or in accordance with 8.3.2 in NZS 6802:2008.
Rating level	A derived level used for comparison with a noise limit. Considers any and all corrections described in NZS 6801 and NZS 6802, e.g. duration, special audible character, residual sound etc. This definition is from NZS 6802:2008.
Special audible characteristics	Distinctive characteristics of a sound that make it more likely to cause annoyance or disturbance. A penalty of up to 5 decibels can be applied when assessing sounds with SAC Examples are tonality – a hum or a whine) and impulsiveness – bangs or thumps.

APPENDIX B SITE LAYOUT PLAN



