Styles Group
Acoustics & Vibration Consultants

ASSESSMENT OF NOISE EFFECTS

DARFIELD SOLAR AND ENERGY STORAGE PROJECT
1352 HOMEBUSH ROAD

PREPARED FOR

Darfield Solar and Energy Storage Ltd

DATE

27 August 2024

Assessment of construction and operational noise effects prepared by Styles Group for Darfield Solar and Energy Storage Ltd.

REVISION HISTORY

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1	8/08/24	For review	Final Draft	Jon Styles, MASNZ Title Styles Group	Gemma Sands Consultant Styles Group
2	27/08/24	Final	Final		

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Executive summary

Styles Group has predicted and assessed the noise effects from the construction and operation of the proposed Darfield Solar and Energy Storage Project at 1352 Homebush Road (the **Site**). This assessment has been prepared to accompany the resource consent application.

We have used noise modelling software to predict the cumulative noise emissions from the operation of all electro-mechanical solar plant for comparison with the permitted noise limits prescribed by the Partially Operative Selwyn District Plan (Appeals Version) (the **POSDP**). The noise modelling indicates that compliance with the permitted noise levels can readily be achieved at all notional boundaries at adjacent sites in the General Rural Zone as well as future notional boundaries that may establish in the Large Lot Residential Zone.

Noise and vibration generated from the construction phase can be managed to comply with the noise and vibration limits prescribed by the POSDP. We have recommended a condition of consent requiring the applicant to prepare and submit a Construction Noise Management Plan (**CNMP**). The CNMP will set out the specific noise mitigation measures required to achieve compliance.

We have recommended conditions of consent based on our findings.

1.0 Introduction

Darfield Solar and Energy Storage Ltd has engaged Styles Group to predict and assess the noise effects from the construction and operation of the proposed Darfield Solar and Energy Storage Project (the **Project**) at 1352 Homebush Road (the **Site**).

This report includes:

i. An assessment of the operational noise levels in accordance with the relevant noise limits prescribed by the Partially Operative Selwyn District Plan (Appeals Version) (the **POSDP**); and

ii. As assessment of the construction noise and vibration effects in accordance with the relevant construction noise and vibration limits prescribed by the POSDP.

iii. Recommended conditions of consent.

This report should be read in conjunction with the application site plans and the Assessment of Environmental Effects. A glossary of acoustical terms used within this document is attached as Appendix A.

2.0 The proposal

NZ Clean Energy Ltd propose to construct, operate and maintain a 117 MW agrivoltaic solar farm with a 106MW battery energy storage system (**BESS**). The facility will generate renewable electricity using photovoltaic technology. The BESS facility will enable the energy produced on the Site to be stored and discharged into the national grid on demand.

The solar farm will connect to the national grid via the Kimberley substation[1] located on the adjacent site at 3762 Homebush Road.

The project will involve the following noise sources:

- Construction noise over a period of approximately 12-18 months (worst-case)
- Operational noise from the electro-mechanical plant inside the BESS and switchyard area, and from the inverter stations distributed throughout the photovoltaic (**PV**) array. Noise is primarily generated from the thermal management systems (air cooling fans) contained within the plant.
- Operational noise from tracking motors[2] that enable the PV panels to follow the movement of the sun during the day.
- Occasional maintenance activities typically involving quad bike or small farm utility vehicles. The site will be grazed by sheep. Noise from operation and

[1] Designation ORION-18

[2] Tracking systems typically utilise a 24V DC motor

maintenance activities (including vehicle movements) will be intermittent and generate a low level of noise.

Figures 1 and 2 display the site layout and location of the BESS and switchyard. The majority of noise generating electro-mechanical plant (transformers, inverters and batteries) are consolidated within the BESS and switchyard area, with 10 “inverter stations” (each station comprising two inverters and an MV transformer) distributed throughout the PV array.

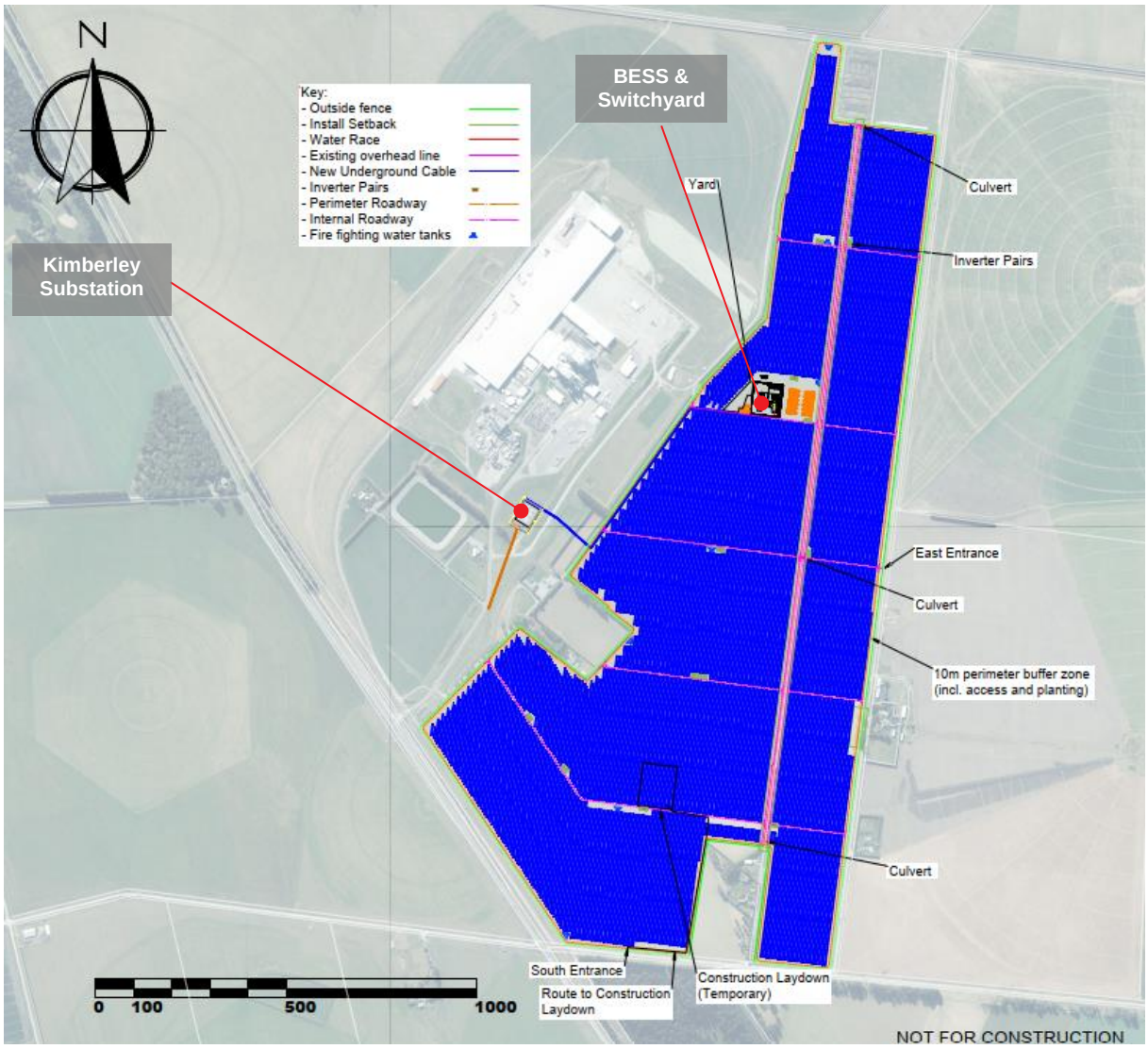


Figure 1 Site layout (DAR-001 19/08/2024)

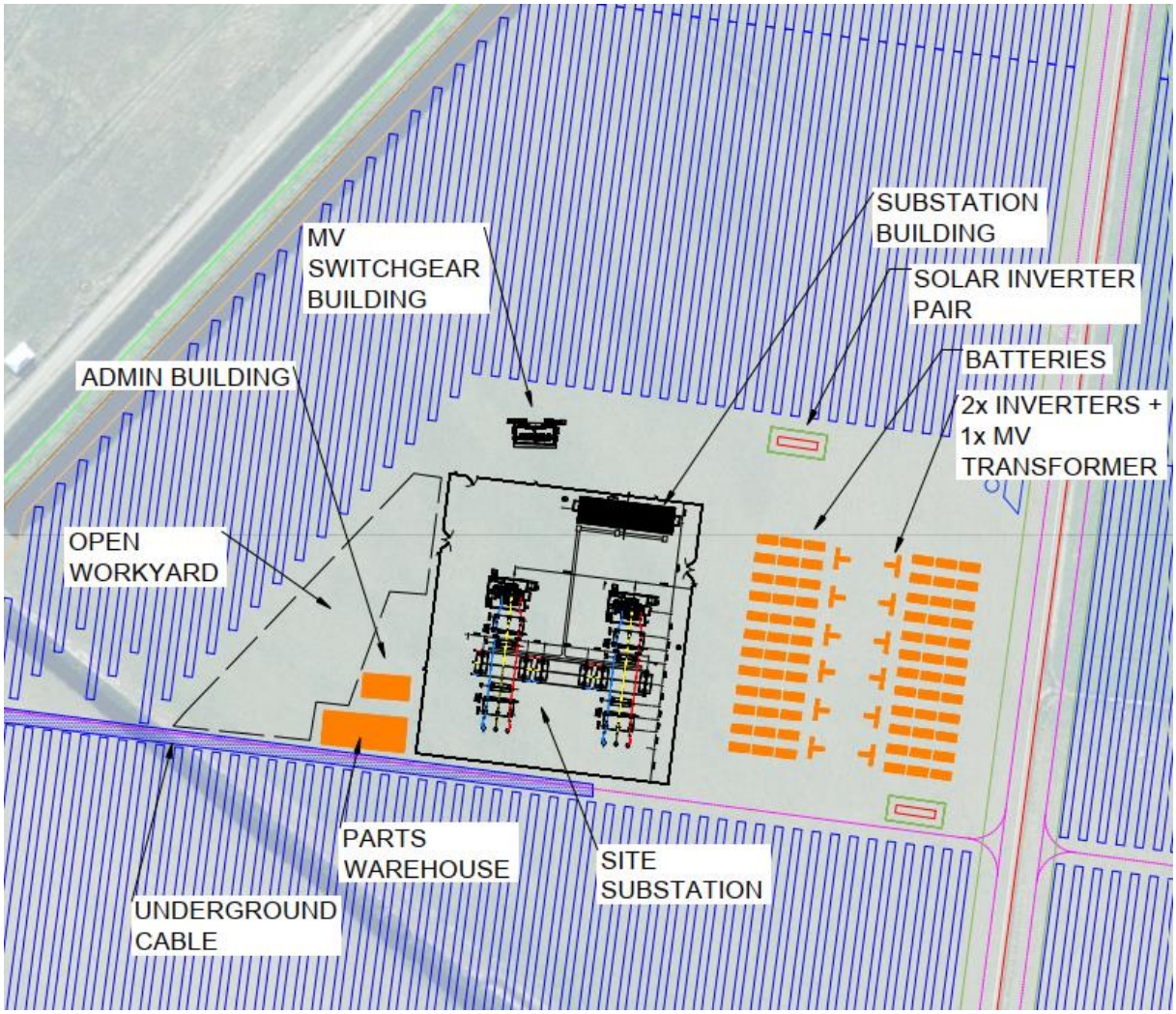


Figure 2 Layout of the BESS & Switchyard

3.0 Zoning of the Site and surrounding area

Figure 3 displays the POSDP zoning arrangements across the Site and surrounding land. The Site and adjacent land to the north and west is in the General Rural Zone (**GRUZ**). The adjacent site to the western boundary is occupied by the Fonterra Kimberley Factory (the **Dairy Factory**) in the Dairy Processing Zone (**DPZ**). Figure 3 displays the location of the Kimberley Substation on the Dairy Factory Site. The Large Lot Residential Zone (**LLRZ**) is located on the southern side of Homebush Road.

Figure 3 shows the extent of the DPZ Noise Control Overlay (**NCO**). The purpose of the NCO is to ensure that any noise sensitive activity established within the overlay is acoustically treated from noise generated from the dairy factory, in accordance with NOISE-R6.

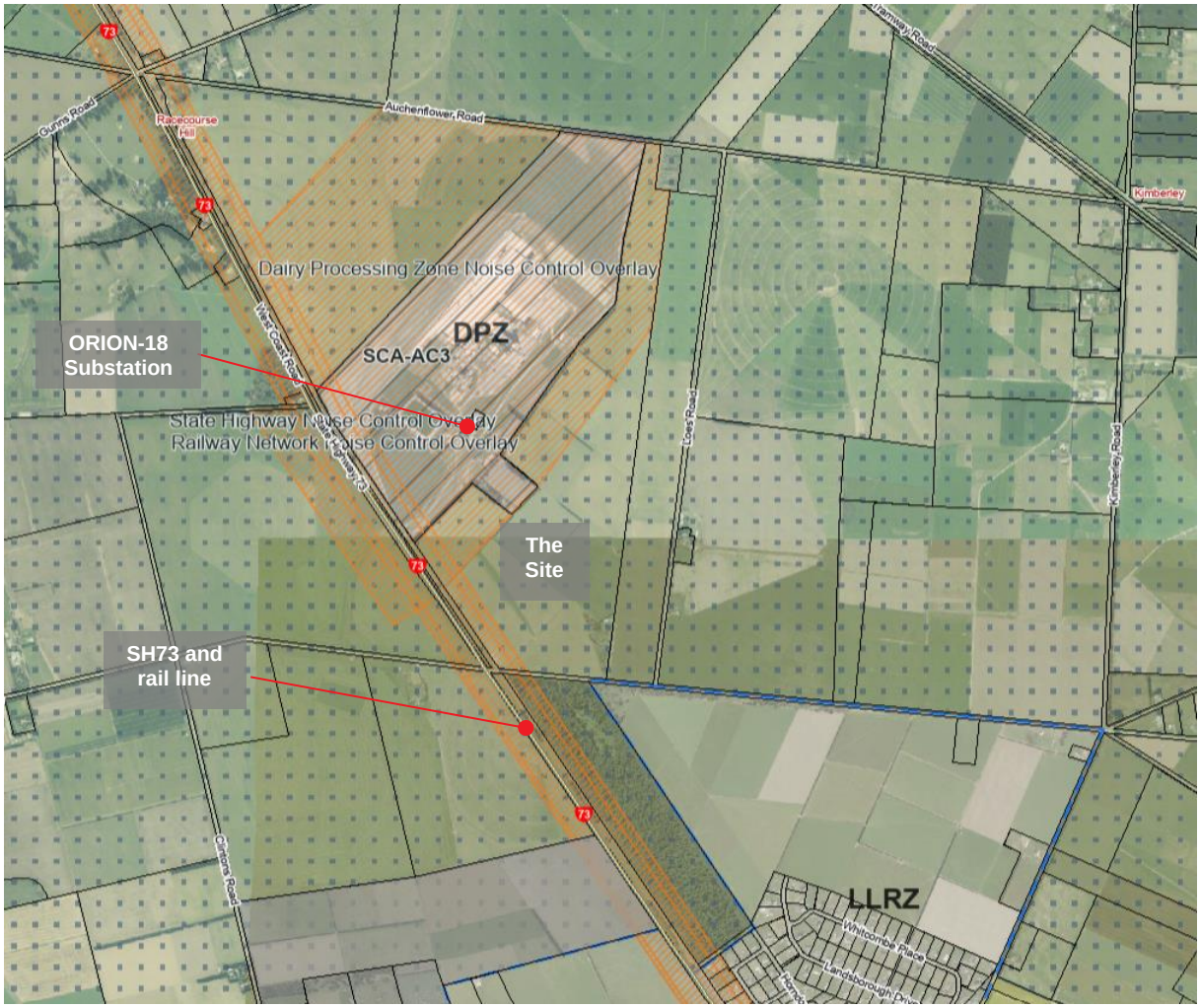


Figure 3 POSDP Zoning of the Site and surrounding area

Figure 3 also displays SH73 and the rail corridor to the west of the Site, and the extent of the State Highway and Rail Network noise control overlays. All buildings containing noise sensitive activities inside the State Highway and Rail Network noise control overlays are required to be acoustically treated in accordance with NOISE-R3.

Figure 3 demonstrates that a significant proportion of the Site is affected by overlays that are designed to ensure noise sensitive activities are designed and constructed to achieve compatibility with the permitted noise environment from the DPZ and land transport. Solar farms are not noise sensitive activities.

4.0 Receivers

The Site is located in a rural environment with a low intensity of residential development surrounding the Site.

The POSDP prescribes operational noise limits that control the noise levels that may be received at the notional boundary[3] of any residential dwelling in the GRUZ or at any part of a site in a Residential Zone (i.e. the LLRZ). The construction noise standards apply when measured and assessed 1m from the façade of any occupied building[4].

Table 1 and Figure 4 identify the closest receivers. Table 1 provides approximate separation distances from the dwelling to the closest proposed operational noise source and the closest potential area of construction work on the Site.

Table 1 Separation distances to closest receivers

ID	Address	Operational noise: Approximate separation distance from notional boundary to closest noise sources	Construction Noise: Approximate separation distance from closest construction work to building façade
Dwellings inside the DPZ and DPZ Noise Control Overlay			
A	1/3792 West Coast Road	>170m to closest inverters >700m to BESS	≈19m to closest PV panel
B	2/3792 West Coast Road	>300m to closest inverters >600m to BESS	≈110m to closest PV panel
C	4/3792 West Coast Road	>400m to closest inverters >750m to BESS	≈200m to closest PV panel
D	3/3792 West Coast Road	>650m to closest inverters >1000m to BESS	>500m to closest PV panel
West Coast Road Dwelling			
E	2171 West Coast Road	>650m to closest inverters >1000m to BESS	>800m to closest PV panel
Loes Road Dwellings			
F	68 Loes Road	>300m to closest inverters >800m to BESS	≈70m to closest PV panel
G	32 Loes Road	>200m to closest inverters >800m to BESS	≈ 50m to closest PV panel

[3] Defined by the POSDP as "means a line 20 metres from any side of a residential unit or other building used for a noise sensitive activity, or the legal boundary where this is closer to such a building".

[4] In accordance with New Zealand Standard NZS 6803:2008 Acoustics - Construction Noise

ID	Address	Operational noise: Approximate separation distance from notional boundary to closest noise sources	Construction Noise: Approximate separation distance from closest construction work to building façade
Homebush Road Dwelling			
H	1352 Homebush Road	>120m to closest inverters >800m to BESS	≈45m to closest PV panel >250m to construction laydown area

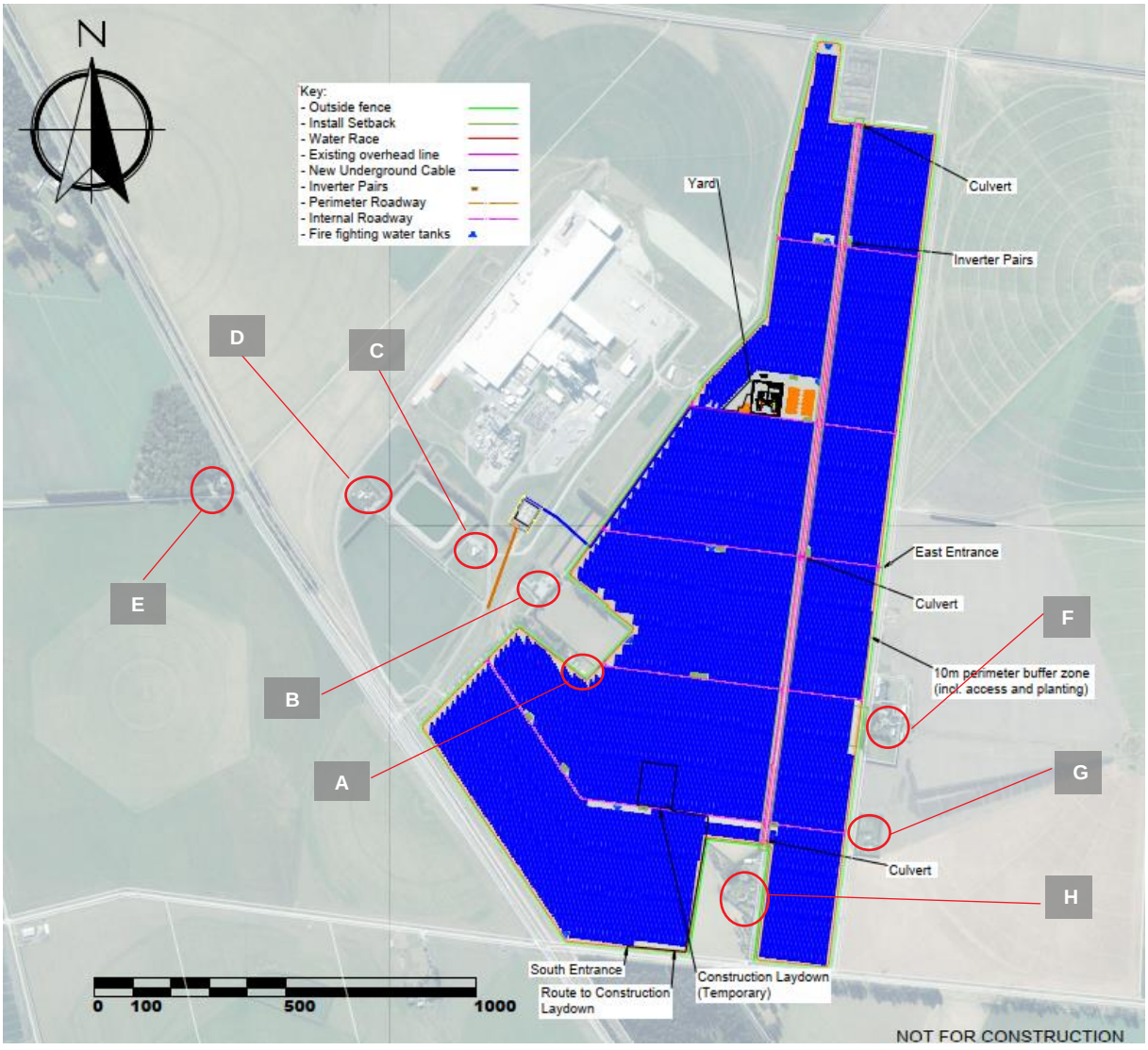


Figure 4 Closest receivers for noise

5.0 Operational noise standards applying to the proposal

We understand that the operational and construction noise and vibration rules in the POSDP that are relevant to the proposal are not subject to appeal and should therefore be treated as operative. These include:

- The operational noise limits in NOISE- REQ1 and NOISE-TABLE5
- The construction noise limits in NOISE-REQ2 and NOISE-TABLE6
- The vibration standards in NOISE-R14 and NOISE-TABLE-R4.

This section is focussed on operational noise. A assessment of construction noise and vibration effects is provided in Section 9.0.

5.1 Operational noise limits

NOISE-REQ1 requires that any activity that generates noise shall meet the noise limits of the zone of the site receiving noise from an activity.

NOISE-TABLE5 prescribes the following noise limits for noise generated from the GRUZ and received at the notional boundary of a dwelling on any other site in the GRUZ, or any site within a Residential Zone (i.e. the LLRZ on the southern side of Homebush Road):

Zone of the site generating noise	Zone of the site receiving noise	Assessment location	Hours and limits
All zones	RESZ	Any point within any site receiving noise	0700 to 2200: 50 dB $L_{Aeq\ (15min)}$ 2200 to 0700: 40 dB $L_{Aeq(15min)}$ / 70 L_{AFmax}
GRUZ	GRUZ	At the notional boundary of any noise sensitive activity within any site receiving noise	0700 to 2200: 55 dB $L_{Aeq\ (15min)}$ 2200 to 0700: 45 dB $L_{Aeq(15min)}$ / 70 L_{AFmax}

NOISE-Overview requires that noise levels must be measured in accordance with NZS 6801:2008 Acoustics - *Measurement of Environmental Sound* and assessed in accordance with NZS 6802:2008 *Acoustics - Environmental Noise*.

The proposal is to comply with the noise limits in NOISE-TABLE5. The noise modelling indicates that compliance with the permitted noise standards can be readily achieved at all assessment locations.

6.0 Operational noise modelling and predictions

We have used Brüel & Kjær Predictor computer noise modelling software to predict the operational noise effects from the electro-mechanical plant located in the following areas:

i. The BESS and switchyard area

ii. The inverter stations distributed throughout the PV array.

The predictions are based on the methods in International Standard ISO 9613-1/2 *Acoustics – Attenuation of sound during propagation outdoors*. The calculations assume meteorological conditions that slightly enhance propagation in all directions in accordance with NZS 6801:2008. The Brüel & Kjær Predictor software is globally recognised and has been successfully implemented on many projects throughout New Zealand.

The noise models are based on the following assumptions.

6.1 BESS and switchyard facility

The BESS will enable the energy produced on the Site to be stored and discharged into the national grid, as required to meet demand during peak periods (predominantly during the evening period).

The BESS and switchyard facility has been located to achieve the greatest separation distances from existing and future notional boundaries in the GRUZ and LLRZ and for its proximity to the Kimberley substation.

The BESS and switchyard facility is expected to include the following noise sources:

i. **72 battery containers:** The batteries are designed to operate in a controlled temperature environment. The containers that house the batteries include HVAC systems to regulate the thermal environment of the batteries. The noise modelling assumes a worst-case scenario where all container HVAC systems are operating at full load, during the day or night. In reality, the HVAC systems are only likely to operate at full load when the batteries are charging or discharging at a high rate. The noise model assumes that the batteries are oriented with the HVAC unit facing into the Site (and away from the nearest receivers).

ii. **Substation HV transformer:** Transformer noise is generated from the electromagnetic hum generated by the coils changing the current, and the cooling fans that keep the plant cool when it operates at high load.

iii. **12 power station inverters (each containing two inverters and 1 MV transformer):** Noise is generated from the operational hum that occurs when DC power stored in the batteries is converted to AC power used in the grid. The inverters also include cooling fans.

6.2 Power station inverter units distributed across the PV array

Ten power station inverter units (each including include one pair of inverters and one MV transformer) are distributed throughout the PV array. These units generate noise when the PV array is generating electricity during daylight hours. The plant will idle and generate no or only a very low level of noise during low light conditions.

6.3 Noise model parameters

The noise model has been prepared using terrain contours, building footprints and parcel boundaries from Land Information New Zealand and information provided by the Project Team. The topographical contours encompass the entire site and a large area of the surrounding land. We have ensured the integrity of the noise model by careful scrutiny of the final three-dimensional model.

The noise model takes into account the screening provided by the PV panel structures.

The input parameters for the noise model are set out in Table 2.

Table 2: Predictor noise model input parameters

Parameters/calculation settings	Details
Software	Brüel & Kjær Predictor V2024
Calculation method	ISO 9613.1/2
Meteorological parameters	Single value, C0 = 0
Ground attenuation over land	General method, ground factor: 0.8 (grazed pasture)
Air temperature	293.15 K
Atmospheric pressure	101.33k Pa
Air humidity	60%
Switchstation plant	- 1 switch-gear building with HVAC - 1 HV transformer
BESS plant	- 72 air-conditioned battery containers (Saft) - 14 Proteus PCS Stations (comprising 2 inverters plus 1 MV transformer)
Inverter stations throughout PV array	- 10 Proteus PV Stations (comprising 2 inverters plus 1 MV transformer)
On time assumptions- daytime	All plant operating at 100%
On time assumptions- night time	BESS and switchstation plant operating at 100%. Inverter stations in the array idling.

6.3.1 Sound power levels of plant items

The noise model is based on the manufacturer sound power level specifications for the Saft batteries and Gamesa Proteus PV Stations provided to us by the Project Team.

Table 2 includes the frequency spectrum data for an HV transformer inside the switchstation area. We have applied a +5dB adjustment to the HV transformer noise to allow for potential tonal noise that would require a +5dB adjustment for special audible character, in accordance with NZS6802:2008.

Table 3: Frequency spectrum data for HV transformer

Plant	Octave band sound power levels (dB Lw)								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dBA
HV Transformer	91	93	88	88	82	77	72	65	93 dB *(includes +5 dB special audible character adjustment in accordance with NZS6802:2008)*

6.3.2 Operating assumptions

We have used noise modelling software to calculate the noise levels expected to be generated by plant during the prescribed daytime and night time periods.

Section 6.4 of NZS6802:2008 provides for a duration adjustment (of up to 5dB) to be made if noise is intermittent during the prescribed daytime period. No adjustment has been applied for duration as the noise model assumes a worst-case scenario where all plant is operating at maximum load throughout the day.

The operating assumptions are described below.

6.3.2.1 Daytime noise

The daytime noise model assumes a worst-case scenario where all plant is operating at 100% load during the day time period. We understand that in reality:

1. The BESS plant will operate at full load when the plant is charging or discharging at a high rate. We understand that the noise levels from the BESS plant operating at maximum discharge rates will be confined to short periods when demand for electricity peaks. The noise emissions from the BESS discharging at slower rates will result in a lower level of noise emissions.
2. The inverter power stations throughout the PV array will only generate noise when generating electricity in sunny conditions. The inverters will idle and generate no or only a very low level of noise during low light conditions.

6.3.3 Night time noise

The nighttime noise model is based on the same assumptions for the daytime noise model, except that the model excludes the inverter power stations throughout the array that will idle during the night time period. The main night time noise source is the possible discharge of the BESS.

6.4 Noise levels from tracking system motors

The solar panels will be mounted using a tracking system that enables the panels to rotate to follow the movement of the sun. Tracking systems typically utilise a 24V DC motor. Our review of the sound power level data for tracking system motors confirms the level of noise emissions is very low[5] and will be much lower than the plant. Tracking motor noise levels are not included in the noise model due to their very low noise levels. The cumulative noise levels from plant noise and tracking motors will readily comply with the noise limits.

7.0 Noise level contours and predictions

The noise level contours in Appendix B illustrate the likely propagation of noise levels from the Site for comparison with the POSDP daytime and night time noise limits.

7.1 Daytime noise levels

The daytime noise model indicates the noise levels from the Site during the daytime period.

The noise level contours show that the highest noise levels are predicted to be received at the notional boundary of 1352 Homebush Road (42 dB L_{Aeq}) and 1/3792 West Coast Road (41 dB L_{Aeq}). The predicted noise levels at these receivers are at least 13-14 dB lower than the permitted daytime noise levels in the GRUZ (55 dB L_{Aeq}).

All other receivers are predicted to receive noise levels less than 40 dB L_{Aeq} during the daytime period.

7.2 Nighttime noise levels

The nighttime noise model indicates the noise levels from the Site during the nighttime period.

Nighttime noise generated from the Site must comply with a noise limit of 45 dB L_{Aeq} when measured and assessed at any notional boundary in the GRUZ, and 40 dB L_{Aeq} when measured and assessed at the boundary of any site in the LLRZ.

All receivers in the GRUZ and DPZ are predicted to receive noise levels less than 40 dB L_{Aeq} during the nighttime period.

The noise levels in the LLRZ are predicted to be lower than 30 dB L_{Aeq} during the nighttime period.

7.2.1 Noise effects across vacant land

We have reviewed the noise contours to determine whether the proposal is at risk of encroachment from the establishment of new notional boundaries (dwellings) on vacant sites.

[5] Based on NexTracker Motor Sound Test Summary

Activities are typically vulnerable to encroachment where vacant land surrounding the site is used as a buffer for noise emissions. In this case, the daytime noise contours indicate that the noise levels across all adjacent sites in the GRUZ will be lower than 50 dB L_{Aeq}. Noise levels generated from the Site during the daytime period will not exceed the permitted noise limits at any existing or future notional boundary.

The indicative nighttime noise contours indicate that the noise levels across all adjacent sites will be lower than 45 dB L_{Aeq}, except for the very small area of land on 32 Loes Road displayed in Figure 4. 32 Loes Road is occupied by a residential dwelling. The noise levels at the dwelling on 32 Loes Road are predicted to be lower than 40 dB L_{Aeq}.

We consider that the risk of encroachment is low as the noise levels across all adjacent vacant sites will be lower than the permitted noise standards for the GRUZ and LLRZ.

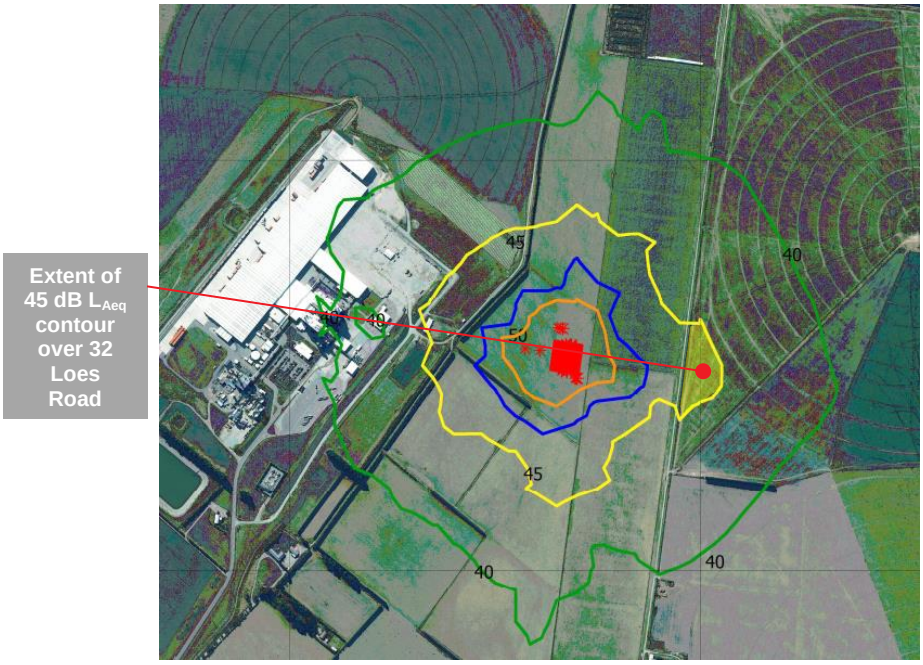


Figure 5 Night time noise contour across 32 Loes Road

8.0 Assessment of operational noise effects

We understand that the National Policy Statement for Renewable Electricity Generation 2011 provides for, as a matter of national significance, the development, operation, maintenance, and upgrading of new and existing renewable electricity generation activities, including solar. It is generally recognised that the utility scale solar farms rely on rural land to establish and operate, and that mechanical plant is an expected feature of solar farms.

We understand that the POSDP seeks to encourage more sustainable, renewable electricity generation within the District (E1- Overview). Policy EI-P4[6] seeks to ensure that the noise and

[6] Under appeal

vibration effects from the construction and operation of renewable electricity generation are managed. We consider that this means that the noise from infrastructure associated with renewable energy facilities such as the DAR can be reasonably expected in the GRUZ, and the noise limits for permitted activities are relevant.

The BESS and switchstation plant have been located to achieve ample separation distances from existing dwellings. The noise modelling we have undertaken demonstrates that the noise emissions will readily comply with the POSDP noise limits at all adjacent sites.

The noise level contours in Appendix B represent the “worst-case” scenario for daytime and night time noise levels, where all electro-mechanical plant is operating at maximum load. The noise levels from the BESS will be much lower when the BESS is operating at lower discharge rates during the day or night. The inverter stations will idle during the night and will generate a reduced level of noise in low light conditions.

Noise from all other operational noise sources such as ongoing general site operation, maintenance activities (including vehicle movements) will be intermittent and generate only a low level of noise. These noise sources will readily comply with the POSDP noise standards.

The Site is located in the context of a noise environment controlled by the Dairy Factory, SH73, and the rail corridor. A significant proportion of the Site is subject to the Dairy Processing Zone, State Highway and Rail Network Noise Control Overlays that require the acoustic treatment of any noise sensitive land use. Solar farms are not noise sensitive activities, and therefore the proposed use of the Site will be compatible with the existing noise environment.

Overall, we consider that the closest receivers may be likely to hear the solar plant operating from time to time. The most audible periods will occur when periods of high demand or high energy production coincide with periods when the ambient noise environment is very low and during calm meteorological conditions. We expect that these occasions will be very limited due to the proximity of the Dairy Factory and SH73.

Overall, we consider that the potential noise emissions from the proposed activity will be reasonable for all receivers.

9.0 Assessment of construction noise and vibration effects

9.1 Construction noise limits

NOISE-REQ2 requires that any activity that generates construction noise shall meet the noise limits set out in NOISE-TABLE6.

NOISE-TABLE6 Construction Noise Limits

	Time of week	Time period	Duration of work		
			Typical duration (dBA)	Short-term duration (dBA)	Long-term duration (dBA)
RESZ, and residential units and minor residential units in: GRUZ CHVZ CORZ FHSVZ HOHZ GRAZ KNOZ MPZ PRZ TEZ	Weekdays	0630-0730	60 L_{eq} / 75 L_{max}	65 L_{eq} /75 L_{max}	55 L_{eq} /75 L_{max}
		0730-1800	75 L_{eq} /90 L_{max}	80 L_{eq} /95 L_{max}	70 L_{eq} /85 L_{max}
		1800-2000	70 L_{eq} /85 L_{max}	75 L_{eq} /90 L_{max}	65 L_{eq} /80 L_{max}
		2000-0630	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
	Saturdays	0630-0730	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
		0730-1800	75 L_{eq} /90 L_{max}	80 L_{eq} /95 L_{max}	70 L_{eq} /85 L_{max}
		1800-2000	45 L_{eq} / 75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
		2000-0630	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
	Sundays and public holidays	0630-0730	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
		0730-1800	55 L_{eq} /85 L_{max}	55 L_{eq} /85 L_{max}	55 L_{eq} /85 L_{max}
		1800-200	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}	45 L_{eq} /75 L_{max}
		2000-0630	45 L_{eq} /75 L_{max}	45 L_{eq} / 75 L_{max}	45 L_{eq} /75 L_{max}

Figure 6 Construction Noise Limits in NOISE-TABLE6 (relevant column in red)

The POSDP does not specify the noise measurement or assessment methods and does not refer to any New Zealand acoustical standard. We note that Mandatory Direction 1 of the Noise and Vibration Metrics Standard (**NVMS**) in the National Planning Standards requires that any plan rule to manage noise emissions must be prescribed accordance with the mandatory noise measurement methods and symbols in the applicable New Zealand Standard incorporated by reference. NZS6803:1999 is identified as the relevant acoustical standard for construction noise and should therefore be referred to in the POSDP.

We also note that the POSDP does not specify the relevant location where the construciton noise limits must be measured and assessed. NZS6803:1999 specifies that the noise levels from construction work are required to be assessed at the façade of any occupied building[7] and typically over a 15-to-60 minute period.

We have interpreted NOISE-R6 in accordance with the relevant procedures prescribed in NZS6803:1999, including NZS6803:1999's definitions for the terms "typical" short term" and "long-term" (these terms are not defined by the POSDP). We understand that the construction phase will extend for up to 18 months and is therefore subject to the construction noise limits for long-term duration projects[8] that are shown in Figure 6 above.

Construction activity will take place between 7:30am and 6:00pm, Monday to Saturday, when NOISE-TABLE6 prescribes a noise limit of 70 dB L_{Aeq} and 85 dB L_{AFmax} at any dwelling in the GRUZ. NZS6803:1999 requires that the noise levels are measured and assessed 1m from

[7] The limits apply at 1 m from the façade and 1.2 to 1.5 m above the relevant floor level of any building that is occupied during the works. They do not apply at unoccupied buildings.

[8] More than 20 weeks (long-term duration)

the building façade and that the noise limits only apply if the dwelling is occupied at the time of works.

The proposal is to comply with the construction noise limits in NOISE-TABLE6.

9.2 Construction vibration

NOISE-R14[9] and NOISE-TABLE4 prescribes vibration thresholds for any land use activity generating vibration effects. The proposal is to ensure that any vibration generated from construction work complies with the vibration thresholds in NOISE-TABLE4. Table 4 is reproduced below.

NOISE-TABLE4 Vibration Thresholds								
All Zones	Type of Structure	Vibration Threshold for Structural Damage, PPV (mm/s)						
		Short Term					Long-term	
		At Foundation, at all directions			Topmost Floor, horizontal direction	Floor slab, vertical direction	Topmost Floor, horizontal direction	Floor slab, vertical direction
		1-10Hz	10-50Hz	50-100Hz	All frequencies	All frequencies	All frequencies	All frequencies
	Commercial activity and Industrial Activity	20	20 to 40	40 to 50	40	20	10	10
	Residential Activity	5	5 to 15	15 to 20	15	20	5	10
	Sensitive Activity, excluding Residential Activity and Heritage Items	3	3 to 8	8 to 10	8	20	2.5	10

The vibration thresholds specified in NOISE-TABLE4 are concerned with building damage. The activities likely to generate the highest level of vibration include the operation of tracked excavators, and other heavy plant and vehicles, and small-scale piling to install PV panels.

[9] We note that NOISE-R14 and NOISE-TABLE4 have not been drafted in accordance with the technical requirements of the NVMS of the NPS. Mandatory direction 3 of the NVMS requires that any plan rule to manage damage to structures from construction vibration must be prescribed in terms of peak particle velocity (PPV) in ISO-4866:2010 – Mechanical vibration and shock. The POSDP does not refer to the procedures specified in ISO-4866:2010 for the measurement and assessment of vibration. We also note that NOISE-R14 and NOISE-TABLE4 do not define the terms “long term” and “short term”.

The nearest structures on the adjacent sites that have the potential to receive vibration from construction work on the Site are occupied by residential activity. Buildings containing commercial and industrial activity (i.e. the Dairy Factory and Kimberley substation) are well separated from all areas of construction work on the Site.

We have not identified the potential for any potential construction activities on the Site to approach or exceed the relevant vibration limits specified in NOISE-TABLE4 due to the separation distance to all adjacent structures on adjacent sites. We consider that compliance with the thresholds in NOISE-R14 and NOISE-TABLE4 can be achieved without the need for any specific mitigation.

9.3 Construction noise sources

We understand that the peak construction phase will involve the following activities and noise sources:

- Delivery of construction materials (up to 30 heavy vehicle movements and 120 light vehicle movements per day).
- Civil works – involving construction of temporary facilities, fencing, trench excavation, levelling of substation area, construction of internal roading, excavation for equipment foundations and concrete pouring.
- Installation of plant, cabling and other electrical and auxiliary equipment
- Pile driving of panel structures
- Installation of panel structure and modules
- Installation of inverters and DC batteries
- Cabling and wiring from field to switchgear
- Installation of switchgear, transformers and AC batteries
- Final road surfacing

The proposal is to undertake all noisy construction work and heavy vehicle movements between 7:30 am and 6:00 pm, Monday to Saturday. There will be no noisy works in the evening or on Sundays. Noisy construction works include earthworks, trenching, piling, PCU installation, use of generators and air compressors and heavy vehicle movements.

Quieter activities may be undertaken outside of these hours if they are generally inaudible at the neighbouring sites. This may include electrical testing and commissioning, bracket installation, cable management works, surveying, office and administrative work, PV module installation, use of hand tools and light vehicle movements.

9.4 Minimum setback distances to achieve compliance with construction noise standards

Appendix C provides minimum separation distances for construction noise sources that are expected on Site.

The unmitigated separation distances represent the distances that the activities can be undertaken from the most exposed ground-level facade of the nearest occupied building whilst remaining compliant with the consented noise limits and with no mitigation in place.

The mitigated separation distances represent the distances that the activities can be undertaken from the most exposed ground-level facade of the nearest occupied building whilst remaining compliant with the consented noise limits and with mitigation in place.

Noise source levels are based on our database of construction noise measurements undertaken by Styles Group on numerous projects nationwide. They are in accordance with best practice and are generally consistent with guideline noise data provided in NZS 6803:1999 Appendix C *Guide to Sound Level Data on Site Equipment and Site Activities*.

9.5 Closest receivers and compliance with construction noise standards

The noisiest aspect of the proposed construction activity is expected to involve the use of a piling rig to install the panel structures. Noise from the use of a piling rig is predicted to comply with the relevant noise limits where dwellings are more than 50m from the piling rig. The compliance distances are reduced when mitigation (i.e. physical screens) are used to effectively screen line of sight between the rig and the dwelling[10].

All other construction noise sources (including heavy vehicle movements) are predicted to comply with the construction noise limits without the need for mitigation. This is due to the separation distance between the areas of proposed construction work and the closest occupied buildings on adjacent sites, and because the construction works will be undertaken between 0730 and 18000, Monday to Saturday11 when NOISE-TABLE6 prescribes a noise limit of 70 dB L_{Aeq} and 85 dB L_{AFmax} for long-term duration projects.

We have identified that the noise generated from piling works may require mitigation using scheduling[12] or physical mitigation (screening) or alternate piling methods[13] to comply with the permitted construction noise limits in circumstances where a piling rig is used within 50m of any dwelling. The closest dwellings within 50m of the proposed construction work include:

1. 1/3792 West Coast Road. However, we note that the construction noise limits in Rule NOISE-REQ2 do not apply to dwellings/ minor dwellings in the DPZ.

[10] We understand the closest dwellings are single story.

[12] To complete the work when no one is home.

[13] Such as auger, screw or bored piling

2. 1/352 Homebush Road in the GRUZ
3. 32 Loes Road in the GRUZ.

The dwelling on 68 Loes Road is approximately 70m from the nearest panel structure. Piling noise is expected to comply with the construction noise limits at this dwelling without any physical mitigation.

We have recommended a condition requiring the applicant to prepare and implement a Construction Noise Management Plan (**CNMP**) that is to be submitted to Council prior to commencement of construction works. The CNMP will be used to outline the noise mitigation methods that must be adopted when piling works are in proximity (50m) to the closest receivers to enable compliance with the construction noise limits. Mitigation methods may include use of alternative piling methods (i.e. auger, screw or bored piling), use of screening or completing the works when the building is not occupied.

The construction noise levels are expected to comply with the noise limits at other occupied buildings and dwellings. We have not identified any concerns relating to vibration effects given the proposed construction activities and separation distances to the receivers (including the closest receivers identified above).

10.0 Recommended conditions of consent

We recommend the following conditions of consent are imposed to control operational and construction noise and vibration effects from the Site:

1. **Acoustic design report for detailed design**

   The consent holder shall provide Council with an acoustic assessment from a suitably qualified and experienced acoustic expert that demonstrates the selected plant and layout will achieve compliance with the noise limits in Condition 2.

   The report shall include an assessment of the cumulative sound power levels for all electro-mechanical plant and confirm any proposed mitigation measures that must be incorporated in the layout, design and operation of the activity.

   The report shall be provided to the Council a minimum of 6 weeks prior to construction of the solar farm.

2. **Operational noise limits**

   The noise (rating) level from the operation of the solar farm shall comply with the following noise levels when measured and assessed at:

   i. The notional boundary of any dwelling on another site in the GRUZ

Timeframe	Noise limit
7:00am to 10:00pm	55 dB L_{Aeq}
10:00pm to 07:00am	45dB L_{Aeq} and 70 dB L_{Amax}

ii. Within the site boundary of any site in a Residential Zone:

Timeframe	Noise limit
7:00am to 10:00pm	50 dB L_{Aeq}
10:00pm to 07:00am	40dB L_{Aeq} and 70 dB L_{Amax}

Operational noise levels shall be measured in accordance with New Zealand Standard NZS 6801:2008 A*coustics – Measurement of Environmental Sound* and assessed in accordance with the requirements of New Zealand Standard NZS 6802:2008 *Acoustics – Environmental noise*

3. Construction noise levels

Construction noise levels at the façade of any occupied dwelling or minor dwelling* in the GRUZ or Residential Zone shall comply with the following limits, when measured and assessed in accordance with NZS 6803:1999: *Acoustics – Construction Noise*:

Time period	Maximum noise levels	
	$L_{Aeq(15min)}$	L_{AFMax}
6:30am-7:30am, Monday to Friday	55 dB	75 dB
7:30am- 6:00pm, Monday to Saturday	70 dB	85 dB
All other times and on Public Holidays	45 dB	70 dB

*These noise limits shall not apply at any building where a written approval has been provided for construction noise exceedances.

Advice Note: The limits above represent the noise limits for a "long-term" construction project (exceeding 20 weeks). The construction noise limits do not apply at any building that is unoccupied during works.

4. Construction noise management plan (CNMP)*

The consent holder shall prepare and submit a CNMP to Council a minimum of 10 days prior to commencement of construction work. The objective of the CNMP is to set out the methods and procedures that will be used to ensure compliance with the relevant noise limits in NZS 6803:1999: *Acoustics – Construction Noise*.

The CNMP shall set out:

a) The applicable permitted noise standards

b) The programme of works, including construction phasing and hours of operation

c) Identification of surrounding noise sensitive receivers

d) Written communication with occupants of all occupied dwellings or minor dwellings that are within 50m of proposed piling works at least ten (10) days prior to the commencement of activities on site. The written advice shall set out:

(i) a brief overview of the construction works.

(ii) the working hours and expected duration,

(iii) all mitigation measures to be implemented.

(iv) the procedure for recording concerns/complaints regarding noise.

(v) Details of the management and mitigation measures required to comply with the relevant noise limits when piling works are undertaken within 50m of any occupied building that has not provided written approval.

**Recommended condition 4 does not apply if all receivers (dwellings or minor dwellings) within 50m of the extent of works provide their written approval to authorise temporary exceedances of the construction noise limits.*

11.0 Conclusion

Styles Group has assessed the noise effects from the construction and operation of a solar farm in Darfield. We have undertaken noise modelling to determine the cumulative noise levels from the operation of the solar plant during the daytime and night time periods for comparison with the noise limits prescribed by the POSDP.

The noise modelling indicates that compliance with the permitted noise levels can readily be achieved at all notional boundaries at adjacent sites in the General Rural Zone as well as future notional boundaries that may establish in the Large Lot Residential Zone. Noise levels from all other operational and site maintenance activities will be managed to comply with the POSDP noise limits.

Noise generated from the construction phase will be managed to comply with the construction noise limits and construction vibration will readily comply with the relevant limits prescribed by the POSDP. We have recommended a condition of consent requiring the applicant to prepare and submit a Construction Noise Management Plan (**CNMP**). The CNMP will set out the specific noise mitigation measures required to achieve compliance during piling works.

Appendix A Glossary of terms

Noise	A sound which serves little or no purpose for the exposed persons and is commonly described as 'unwanted sound'. The definition of noise includes vibration under the Resource Management Act.
dB (decibel)	The basic measurement unit of sound. The logarithmic unit used to describe the ratio between the measured sound pressure level and a reference level of 20 micropascals (0 dB).
A-weighting	A frequency filter applied to the full audio range (20 Hz to 20 kHz) to approximate the response of the human ear at lower sound pressure levels.
Ambient noise	Ambient noise is the total of all noise within a given environment, comprising a composite of sounds from sources near and far.
$L_{Aeq(t)}$ (dB)	The A-weighted equivalent sound pressure level with the same energy content as the measured varying acoustic signal over a sample period (t). The preferred metric for sound levels that vary over time because it takes into account the total sound energy over the time period of interest.
L_{AFmax} (dB)	The maximum A-weighted sound pressure level recorded during the measurement period using a fast time-weighting response.
L_{WA} (dB)	Sound power level (LWA) is the acoustical energy emitted by a sound source. It is an absolute value and is not affected by distance or the environment. The LWA is used in computer noise modelling to calculate the sound pressure level (e.g. LAeq) at a given distance.
Noise rating level	A derived noise level used for comparison with a noise limit.
Notional boundary	A line 20 metres from any side of a residential unit or other building used for a noise sensitive activity, or the legal boundary where this is closer to such a building.
NZS 6801:2008	N.Z. Standard NZS 6801:2008 Acoustics – Measurement of environmental sound.
NZS 6802:2008	N.Z. Standard NZS 6802:2008 Acoustics – Environmental noise.
NZS 6803:1999	N.Z. Standard NZS 6803:1999 Acoustics – Construction noise.
The Act	The Resource Management Act 1991.
s16	Section 16 of the Act 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".
ISO 9613-1/2	International Standard ISO9613-1/2 Attenuation of sound during propagation outdoors
PPV	Peak particle velocity, measured in mm/s. The standard metric for the measurement of ground borne vibration in New Zealand. The instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position.
CNVMP	Construction noise and vibration management plan. A document to help the contractor manage noise and vibration emissions during construction works.

Appendix B Indicative noise level contours

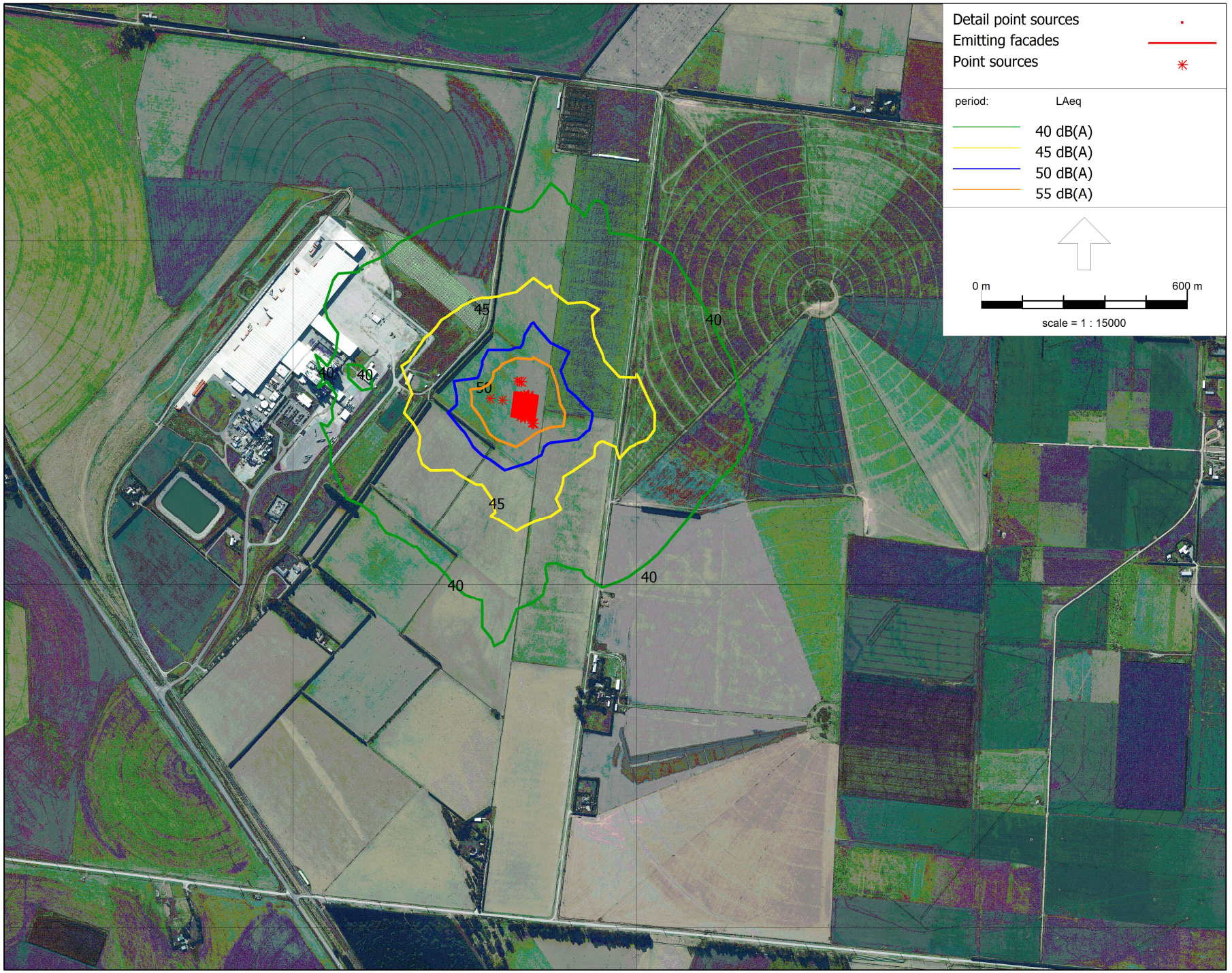
Noise level contours dB L_{Aeq}- Daytime

ISO 9613, [version of Area - GRID 24.06.24 Darfield solar] , Predictor V2023 rev 1 Licensed to Styles Group, NZ

1.7.24 Darfield solar
1 Jul 2024, 09:45

Styles Group, NZ

Noise level contours dB L_{Aeq}- Nighttime



NIGHT 8.7.24 Darfield solar
11 Jul 2024, 14:57

Styles Group, NZ

ISO 9613, [version of Area - NIGHT 8.7.24 Darfield solar] , Predictor V2023 rev 1 Licensed to Styles Group, NZ

Appendix C Construction noise level predictions

Table 4 sets out minimum separation distances for potential construction noise sources on the Site. These are the shortest distances that the construction activities can be undertaken from the most exposed ground-level facade of the nearest occupied building whilst remaining compliant with the permitted noise limits. For separation distances less than 30 m the ground type has been assumed to be hard and reflective.

If construction activities near to any dwelling are required within the separation distances stated in the table below and no written approval is provided by the occupant, further noise mitigation measures will be required to achieve compliance. These measures shall be specified in the Construction Noise Management Plan (**CNMP**) required by recommended Condition 4.

Noise source levels are based on our database of construction noise measurements undertaken by Styles Group on numerous projects nationwide. They are in accordance with best practice and are generally consistent with guideline noise data provided in NZS 6803:1999 Appendix C *Guide to Sound Level Data on Site Equipment and Site Activities*.

Table 4: Noise sources and calculated separation distances for compliance with noise limits

Construction activity	Reference noise level 10 m from plant	Minimum distance for compliance (unmitigated)	Minimum distance for compliance (mitigated)
Driven piling (ramming machine)	83 dB L_{Aeq}	50 m	20 m
Soilmec drill rig	79 dB L_{Aeq}	39 m	13 m
Directional drill	77 dB L_{Aeq}	31 m	11 m
Plate compactor	77 dB L_{Aeq}	31 m	11 m
14-t bulldozer*	77 dB L_{Aeq}	31 m	11 m
7-t bulldozer*	73 dB L_{Aeq}	20 m	7 m
6-t padfoot roller*	73 dB L_{Aeq}	20 m	7 m
Concrete pump and truck discharging	72 dB L_{Aeq}	18 m	7 m
Front end loader	72 dB L_{Aeq}	18 m	7 m

Construction activity	Reference noise level 10 m from plant	Minimum distance for compliance (unmitigated)	Minimum distance for compliance (mitigated)
Excavator mounted 600 kg drop hammer	72 dB L_{Aeq}	18 m	7 m
Excavation and loading trucks with 30 t excavator**	72 dB L_{Aeq}	18 m	7 m
100 t mobile crane under load	71 dB L_{Aeq}	16 m	6 m
Excavation and loading trucks with 20 t excavator	69 dB L_{Aeq}	13 m	< 5 m
Generator	66 dB L_{Aeq}	10 m	< 5 m
5-t vibratory compaction roller	66 dB L_{Aeq}	10 m	< 5 m
20-t grader*	65 dB L_{Aeq}	9 m	< 5 m
Use of power tools	65 dB L_{Aeq}	9 m	< 5 m
10-t grader*	62 dB L_{Aeq}	7 m	< 5 m
Watercart (10,000L)	62 dB L_{Aeq}	7 m	< 5 m
Idling dump truck	62 dB L_{Aeq}	7 m	< 5 m
5-t static compaction roller	62 dB L_{Aeq}	7 m	< 5 m

* The reference level assumes the plant is making short passes near to the site boundary. When the plant makes longer passes or moves away from the boundary the level will be lower.