PROJECT KEA

Waste to Energy Facility
Acoustic Assessment

Prepared for:

South Island Resource Recovery Limited

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BASIS OF REPORT

This report has been prepared by SLR Consulting NZ Limited (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with South Island Resource Recovery Limited (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
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1 Introduction

South Island Resource Recovery Limited (SIRRL) (the **Applicant**) propose to develop and operate an Waste to Energy (**EtW**) facility in south Canterbury. SLR Consulting NZ Limited (**SLR**) has been commissioned to undertake an assessment of acoustic effects associated with the construction and operation of the proposed facility.

This assessment evaluates the noise effects from the proposed facility against the relevant noise rules set out in the Waimate District Plan (the **Plan**) and predicts the noise levels likely to be generated by the construction and operation of the facility. Where required, appropriate noise control measures to achieve compliance have been recommended.

A glossary of acoustic terminology is provided in **Appendix A**.

2 Site and Project Description

2.1 Project Location

The subject site is situated between the township of Glenavy and the Oceania Dairy Factory. The subject site has an approximate footprint of 150,000 m^2 and is located on *Rural* zoned land, as identified in the Plan, with the main truck railway line running along the western boundary. The immediate surrounding land is also *Rural* zoned (see **Figure 1**).

The closest residential dwellings are north to north-east of the subject site, along Mairos Road, over 500 m from the closest site boundary. The region is sparsely populated with the majority of the land used for wet stock grazing. The Oceania Dairy Factory is located approximately 2 km north-west of the subject site.

2.2 Nearby Receivers

The neighbouring properties to the site are indicated in **Figure 1**, with the nearest residential receivers summarised in **Table 1**. Other receivers not noted in the **Table 1** are located further from the site and therefore the noise levels and effects at these receivers are expected to be the same or lower.

Table 1 Summarised list of receivers identified surrounding the proposed Facility

Figure 3 reference	Property Address	Zone	Comment / Notes
R1	77 Mairos Road	Rural	Property containing two single-storey dwellings.
R2	197 Mairos Road	Rural	Property containing two single-storey dwellings.
R3	190 Mairos Road	Rural	Single-storey dwelling

Figure 1 Aerial Showing Site Location

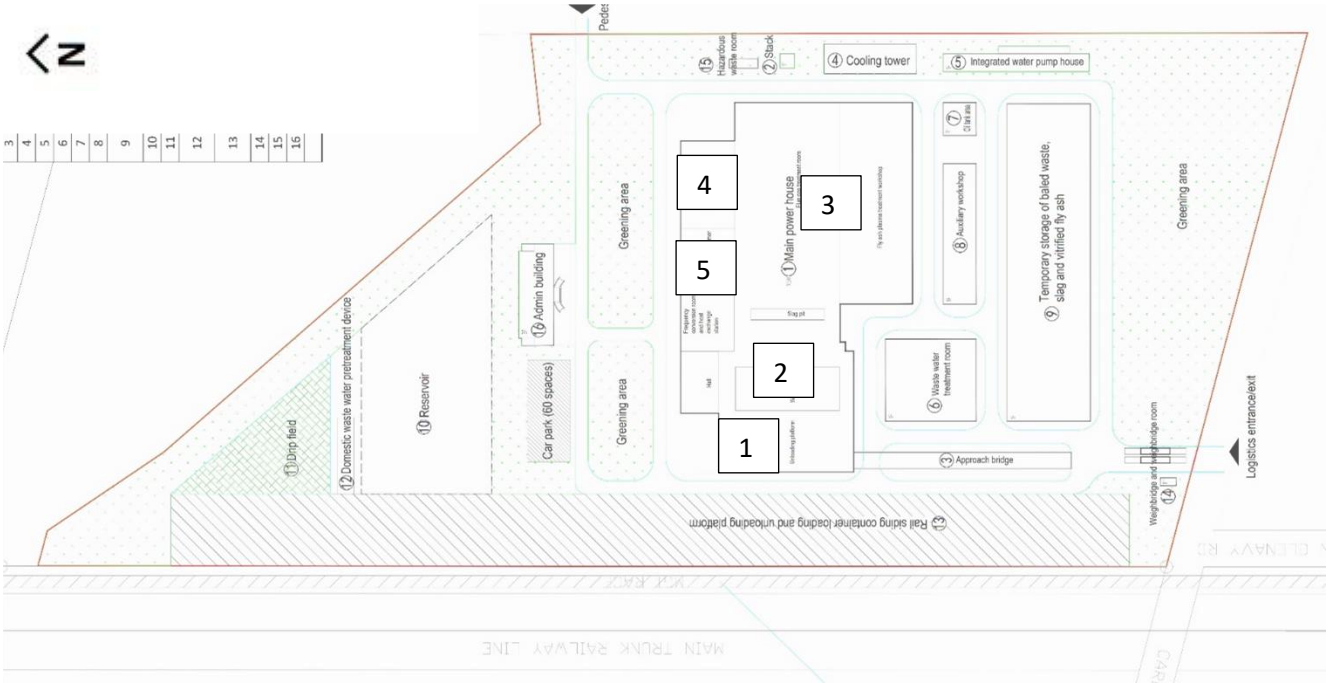
2.3 Project Description

The facility is proposed to operate 24 hours a day 365 days per year. The general operation involves burning feedstock to produce super-heated steam which in turn drives a turbine that generates electricity. The facility is proposed to receive pre-sorted feedstock from several sources such as Municipal Solid Waste (**MSW**) and Construction Waste (**CW**) of up to 1,000 tonnes per day.

Waste would initially be transported to the site by road and eventually by both road and rail. SLR understands that the focus would be on increasing the quantity transported by rail over time.

Process Flow Description

General waste, transported by truck, enters the site from Morven Glenavy Road, near the Carrolls Road end, and in future from rail wagons. The material is unloaded inside the unloading bay (1) where it is conveyed and held in the Waste Bunker (2). The fuel is mixed and fed to the furnace burners to heat up the boiler system, generating super-heated steam contained in the Main Power House (3). The steam is piped to the Turbine Room (4) adjoining the Main Power House, where the steam drives a turbine to produce electricity. The generated electricity feeds into the local network by an onsite transfer room (5), adjoining the turbine room and Main Power House. The proposed site layout dated 4 May 2022 prepared by Babbage Consultants is shown in **Figure 2**.



The majority of the operation of the facility is proposed to take place inside the main enclosed building, approximately 200 m by 130 m. The remainder of the site includes other separate smaller buildings comprising offices, amenities, material storage buildings, water treatment and storage and cooling towers.

Temporary storage of bailed waste product would be stored inside an enclosed structure.

3 Performance Standards

3.1 Construction Noise

Rule 7.18.1 of Section 4 - Rural Zone of the Plan, requires that all construction noise be measured, assessed and complies with the limits of New Zealand Standard *NZS 6803:1999 Acoustics - Construction Noise* (**NZS 6803**). Section 7.2 of NZS 6803 recommends the following noise limits (**Table 2**) for works of longer than 20 weeks (as would be the case in this instance). These limits apply at 1 m from the façade of any dwellings occupied during the works.

Table 2 Recommended upper limits for construction noise received at dwellings in rural areas

Time of Week	Time Period	Long-term duration (more than 20 weeks)	
		L_{Aeq}, dB	L_{Amax}, dB
Weekdays	6:30 am-7:30 am	55	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	65	80
	8:00 pm – 6:30 am	45	75
Saturdays	6:30 am-7:30 am	45	75
	7:30 am – 6:00 pm	70	85
	6:00 pm – 8:00 pm	45	75
	8:00 pm – 6:30 am	45	75
Sundays and public holidays	6:30am – 7:30 am	45	75
	7:30 am – 6:00 pm	55	85
	6:00 pm – 8:00 pm	45	75

3.2 Operational Noise

Rule 7.9 Section 4 - Rural Zone of the Plan sets the following noise limits for noise generated on *Rural* zoned land:

7.9.1 Activities, other than residential activities shall be conducted such that the following noise levels are not exceeded, neither at, nor within, the notional boundary of any residential unit, other than residential units on the same site as the activity:

(a) During daytime *55 dBA (L_{10})*

(b) During night-time *45 dBA (L_{10})*

(c) On any day between 9pm day and 7am on the following *75 dBA (Lmax)*

Except that for farming activities these standards shall only apply to noise from stationary motors or equipment.

7.9.2 Noise levels shall be measured in accordance with the provisions of NZS 6801 Acoustics - Measurement of environmental sound and assessed in accordance with the provisions of NZS 6802 Acoustics - Environmental noise

7.9.3 Noise limits shall not apply to:

(a) activities of a normal recreational nature, such as sporting events, that do not involve powered motorsport, powered aviation, gunfire or amplified music; or

(b) warning devices used by emergency services.

SLR notes that the Plan defines daytime as follows "*for the purpose of noise control daytime means 0700 to 2100 hours Monday to Friday and 0900 to 1700 Saturday, excluding public holidays*".

SLR notes that NZS6801:1991 provides for a time interval of up to an hour. We have adopted a one hour timeframe (before any adjustments for duration would be considered) due to the nature of the noise generated at the proposed facility.

3.3 Resource Management Act

Sections 16 and 17 of the RMA state the following, which applicable to the project:

16 Duty to avoid unreasonable noise

(1) 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."

(2) A national environment standard, plan, or resource consent made or granted for the purpose of any of sections 9, 12, 13, 14, 15, 15A and 15B may prescribe noise emission standards, and is not limited in its ability to do so by subsection (1).

17 Duty to avoid, remedy, or mitigate adverse effects

(1) 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 carried on 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.

(2) The duty referred to in subsection (1) is not of itself enforceable against any person, and no person is liable to any other person for a breach of that duty.

(3) Notwithstanding subsection (2), an enforcement order or abatement notice may be made or served under Part 12 to—

a. require a person to cease, or prohibit a person from commencing, anything that, in the opinion of the Environment Court or an enforcement officer, is or is likely to be noxious, dangerous, offensive, or objectionable to such an extent that it has or is likely to have an adverse effect on the environment; or

b. require a person to do something that, in the opinion of the Environment Court or an enforcement officer, is necessary in order to avoid, remedy, or mitigate any actual or likely adverse effect on the environment caused by, or on behalf of, that person.

(4) Subsection (3) is subject to section 319(2) (which specifies when an Environment Court shall not make an enforcement order).

SLR considers that the compliance with the above Plan performance standards and limits, would satisfy the requirements of the RMA in relation to avoiding unreasonable levels of noise.

4 Construction Noise Assessment

At the time of writing, a detailed programme of construction works, hours and likely plant to be used onsite is not available; therefore, the assessment of construction noise has been based on information and data from SLR's experience working on similar scale developments.

It is understood that construction works would typically occur during the hours of 7:30 am and 6:00 pm, Monday to Saturday. The construction of the project is expected to include clearing and leveling the site, foundations, paving and building erection. A summary of typically expected equipment and associated reference sound pressure levels (**SPLs**) has been provided in **Table 3**. These SPLs are based on in-house measurements undertaken by SLR of other similar activities and published data (BS 5228-1: 2009 *Code of practice for noise and vibration control on construction and open sites – Part 1; Noise*).

The noted approximate setback distances to compliance have been calculated in accordance with the methodology in NZS 6803 and include façade corrections.

Table 3 Construction equipment and typical noise emission levels

Plant Item	Plant Noise Level at 10m	Approximate setback distance to compliance[1] without mitigation
Excavator (<20t) with bucket attachment	75 dB L_{Aeq}	25 m
Vibratory Compaction Roller (≤20 t)[2]	75 dB L_{Aeq}	25 m
Non-vibratory Compaction Roller (<5 t)	60-65 dB L_{Aeq}	10 m
Rotary Piling Rig	80 dB L_{Aeq}	45 m
Concrete Mixer Truck Discharging	75 dB L_{Aeq}	25 m
Driven Impact Piling	85 dB L_{Aeq}	80 m

Notes to Table:

1. NZS 6803 compliance level is 70 dB L_{Aeq}, representative of the day-time limit (7:30 am to 6:00 pm).
2. The setback distance for a non-vibratory compactor is based on 6 movements (passing by an individual receiver) every 15 minutes as the compactor is expected to be moving across the site and not idling/stationary at one location.

Compliance with the 70 dB L_{Aeq} construction noise limit is expected at approximately 80 m from the noisiest activity (impact piling), without mitigation measures such as screening in place.

It is possible that some works, such as early morning concrete pouring, may need to occur outside of typical construction hours and therefore within the night-time hours when the more stringent night-time criteria applies. Compliance with the most stringent night-time 45 dB L_{Aeq} construction noise limit during concrete pouring is expected at approximately 400 m, without mitigation measures such as screening in place.

The nearest existing dwelling is over 500 m from the works, therefore the construction of the facility is expected to comply with the relevant limits of NZS 6803.

5 Operational Noise Assessment

5.1 Noise Modelling Methodology and Assumptions

SLR has predicted operational noise levels generated by the proposed facility in accordance with the algorithms detailed in *ISO 9613-2: 1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*. The ISO 9613 calculation method considers a range of frequency-dependent attenuation factors that include atmospheric absorption, ground attenuation, meteorological conditions (e.g., model assumes meteorological conditions that slightly enhance propagation in all directions in accordance with NZS 6802) barrier effects and the directivity of a noise source.

The noise model takes into consideration the following sources, discussed in more detail in the relevant sub-sections, and shown in **Appendix C**:

- Unloading (**Section 5.2.1**)
- Incineration and Steam Generation (**Section 5.2.2**)
- Turbine and Transformer Room (**Section 5.2.3**)
- Vehicle Movements (**Section 5.2.4**)

Details regarding the supply air ventilation for the incineration and steam generation units have not yet been finalised. It is considered that with proper selection of equipment in terms of noise emission, common methods of noise control such as screening, in-duct attenuators (if required) and appropriate siting, the system can comply with the relevant noise limits. Review of the system design by an acoustic specialist prior to the system design being finalised is recommended.

The acoustic propagation model is based on the following general assumptions:

- All receivers have been calculated as free-field and positioned 1.5 m above receiver level (i.e., ground or first floor level).
- Continuous 24/7 operation of the facility.
- Some elements of the proposal are expected to contain special audible characteristics. On this basis, and to provide a conservative assessment, in accordance with NZS 6802: 1991 a 5 dBA adjustment has been made to the applicable Plan noise limits, for the purpose of assessing compliance.

5.2 Source Description

The noise source information described below, is based on advice provided by the project design team and SLR's experience working on similar energy from waste projects internationally.

5.2.1 Unloading Platform

Vehicles access the unloading platform through an approach bridge and double gate system, to control odours and/or contaminants when vehicles enter the building. This double door system also minimises the level of noise emitted to the environment.

The modelling of this source is based on the following:

- An internal reverberant sound level (L_{Prev}) of up to 70 dB L_{A10} (based on up to 12 trucks entering, unloading and leaving the building within an hour).
- The building facade and roof conservatively being constructed from profile metal cladding, without fibrous insulation (or similar construction), with a sound insulation rating of $R_w \approx 20$ dB.

5.2.2 Incineration and Steam Generation (main power house building)

The Incineration and Steam Generation Room comprises the waste bunker, fuel dosing, combustion air system, steam generation unit and de-ashing system. The combustion process is proposed to operate continuously to provide a stable supply of steam for electricity generation.

The modelling is based on the following:

- An internal reverberant sound level (L_{Prev}) of 90 dB L_{A10}, based on L_{Prev} levels provided to SLR on other similar international projects.
- The building facade and roof conservatively being constructed from profile metal cladding, without fibrous insulation (or similar construction), with a sound insulation rating of $R_w \approx 20$ dB.
- Flue gas would be piped to the stack, which is separate to the main power house building. Both incineration units' stacks would be contained inside a single common housing stack. The main stack has been modelled with a sound power level of 90 dB L_{WA}, based on the cumulative sound power level of two stacks next to each other and the information supplied by the project engineers.

These sources are assumed to operate continuously throughout the day and night.

5.2.3 Turbine and Transformer Room

The turbine and transformer rooms are attached to the main power house building. These house the turbine and generator. Two cooling towers associated with these spaces are located outside to the east.

The modelling is based on the following:

- An internal reverberant sound level (L_{Prev}) of 90 dBA L_{A10} for the Turbine Room.
- An internal reverberant sound level (L_{Prev}) of 85 dBA L_{A10} for the Transformer Room.
- The building facade and roof conservatively being constructed from profile metal cladding, without fibrous insulation (or similar construction), with a sound insulation rating of $R_w \approx 20$ dB.
- Each cooling tower having an assumed sound power level of 105 dB L_{WA} (based on the information supplied by the project engineers).

The L_{Prev} levels for the Turbine Room and Transformer Room are based on the SLR in-house library from other comparable projects. These sources are assumed to operate continuously throughout the day and night.

5.2.4 Vehicle Movements

All vehicle access to the site is proposed to occur via Morven Glenavy Road. Heavy vehicles are proposed to use an access on Morven Glenavy Road on the southern boundary. Light vehicles (staff and visitors) are proposed to use an access on Morven Glenavy Road on the eastern boundary. Vehicle noise associated with the site has been modelled based on information provided by the client and project traffic consultant, summarised below.

Light Vehicle Movements

A total of up to 74 staff are expected to arrive and leave the site per day. SLR has modelled staff vehicle noise at a peak rate of up to 74 light vehicles arriving or departing the site in the busiest hour (day or night).

Heavy Vehicle Movements

Based on the traffic information provided, it is anticipated that up to 68 heavy vehicles would access the site per day. SLR has modelled the peak hour heavy vehicle movement of 6 vehicles (6 trucks arriving and 6 departing) to represent a conservative assessment.

Unloading Trains

A railway siding is proposed along the western boundary of the site. Unloading of containers from trains is proposed to be undertaken by a container stacker operating along the rail siding loading area. This has been modelled as a line source with a sound power level of 105 dB L_{WA} (based on SLR measurement data of similar sized container stackers), assuming unloading of a train could occur continuously over periods of longer than an hour.

Vehicle Source Levels

Vehicle movements were modelled as moving point sources with the following source levels:

- 90 dB L_{WA} for light vehicles (such as cars), and
- 108 dB L_{WA} for Large semi-trailer trucks (such as an ISUZU F-Heavy Series to GIGA Series, Gross vehicle mass 18-29 tonnes or B-trains).
- L_{AFmax} noise levels generated by car doors slamming of approximately 75 dB L_{Amax} at 10 m.
- The release of air brakes by heavy vehicles (perceived as a ‘hiss’) generates the highest levels associated with trucks, measured levels of 85 dB L_{Amax} at a distance of 10 m.

These levels are based on SLR in-house measurements from other comparable projects that involved similar sized vehicles.

5.3 Predicted Operational Noise Levels

The predicted operational rating noise levels are summarised **Table 4** and presented as noise contours in **Appendix B.** The daytime noise levels reported below represent the peak hour of activity anticipated at the facility, noise levels over the whole daytime period are expected to be lower.

Table 4 Predicted Operational Noise Levels

Receiver Number and Address		Predicted Noise Level				Comment
		Daytime Period (dB $L_{A10,1hr}$)		Night-time period (dB $L_{A10,1hr}$)[2]		
		Predicted	Criteria[1]	Predicted	Criteria[1]	
R1	77 Mairos Road	35	50	35	40	Compliance
R2	197 Mairos Road	34	50	34	40	Compliance
R3	190 Mairos Road	36	50	36	40	Compliance

Notes to Table 4:

(1) The daytime and night-time criteria have been reduced by 5 dB in accordance with NZS 6802, due to the noise sources associated with the proposal containing expected special audible characteristics.

(2) Given the distance to receivers, the L_{AFmax} criterion is readily expected to be achieved, therefore the following assessment has not considered this criterion further.

Based on the proposed operation of the facility (**Section 5.2**), the proposal is expected to comply with the Plan daytime and night-time noise limit at all identified existing receivers. Noise levels at other receivers not included in the table above can be expected to comply with the Plan limits as they have a greater separation distance from noise sources and are therefore less exposed to noise.

5.4 Cumulative Noise Effects

A query has been raised by Council regarding the potential for cumulative noise effects at 77 Marios Road when also considering Oceania Dairy noise. The query noted that predicted noise levels from the Oceania Dairy 'Stage 2' expansion were identified at 40 dB L_{Aeq} at that receiver. The predicted worst-case noise level from the proposed WtE facility is 35 dB L_{Aeq} at 77 Marios Road. Should the potential instance of peak activity on both sites occur at the same time this may result in a cumulative level of 41 dB L_{Aeq} at 77 Marios Road, an increase of 1 dB above the Oceania Dairy 'Stage 2' levels.

The effect of a 1-2 dB change in noise levels would be considered negligible as differences of 1-2 dB in noise levels are considered to be imperceptible. Therefore, there would be no expected adverse cumulative noise effect at this receiver.

A number of relevant documents support this statement in an environmental noise context. For example, Section 4 (Table 4.1) of the New South Wales 'Noise Policy for Industry' 2017 (NPfI), defines a residual noise impact of < 2 dB as "negligible". Table 4.2 within the NPfI goes on to describe "negligible" as "…would not be discernible by the average listener…".

5.5 Effects of Traffic and Rail (off site)

The effects of noise and vibration on surrounding dwellings from traffic associated with the proposal when on public roads and from train movements has been raised by Council.

The control of noise and vibration from the road and rail networks is understood to be the responsibility of the network operators – in this case understood to be Waka Kotahi and KiwiRail, and therefore outside of the proponents control. SLR understands that noise and vibration generated on public roads and the rail network are not a consideration or a requirement of the Plan. Nonetheless we have provided comment on these below.

Traffic

Based on information provided, SLR understands that during peak future operation of the site there could be a total of 140 vehicles per day accessing the site. Heavy vehicles could account for up to 65-70 of those vehicles. Vehicles would be expected to reach the site travelling along State Highway 1, accessing the site via Carrolls Road and Morven Glenavy Road.

The traffic flow along State Highway 1 is not expected to be materially changed due to the proposal, and therefore SH1 road traffic noise in the vicinity of the site is not expected to change as a result of this proposal.

Furthermore, SLR notes that there are no dwellings located along the vehicle route via Carrolls Road and Morven Glenavy Road. On this basis, the potential effects of traffic noise and vibration in the area as a result of the proposal are considered to be negligible.

Rail

Rail movements associated with the proposal would be expected to generate similar levels of noise as those generated by existing use of the line. SLR understands that current operation of the rail line provides for train movements at any time of the day and night with the scheduling of train movements controlled by KiwiRail. Depending on demand, rail movements fluctuate across days, weeks and seasons and can therefore vary significantly due to changes at existing operations or new operations up and down the line. Receivers alongside the rail line are already exposed to sporadic noise at various times of the day and night. Therefore, whilst the proposal would add a new user to the rail network it is not expected to materially change noise effects at these receivers.

6 Recommended Conditions of Consent

SLR propose that the conditions of consent should retain the same numerical values but refer to current noise measurement symbols and assessment methods as referred to in *'Section 15 - Noise and Vibration Metrics Standard'* of the *'National Planning Standards'* (Ministry for the Environment dated November 2019). The Waimate District Plan currently refers to outdated noise measurement metric (dB L_{A10}) and superseded standards. Future versions of District Plan are required to adopt the latest noise standards which use the L_{Aeq} metric.

An L_{A10} level is a level which is exceeded for 10% of the specified period and is commonly described as the *'average maximum level'*. An L_{Aeq} level is the energy average of noise during a specified period and is commonly known as the *'average noise level'*. The relationship between the L_{A10} and L_{Aeq} levels are dependent upon the nature of the sound source under consideration; however typically the difference is 2 - 3 decibels (40 dB L_{Aeq} ≈ 42-43 dB L_{A10}). Subjectively, a change in sound levels of 2-3 decibels is generally considered to be on the border of perceptibility. Therefore the effect of altering the noise limit metric from L_{A10} to L_{Aeq} whilst retaining the same numerical values would not be expected to change the effects at surrounding receivers.

SLR recommends that specific conditions of consent be included in the resource consent and provided the following recommended conditions that can be adopted:

1. Construction activities shall meet the guideline limits in *NZS 6803: 1999 Acoustics - Construction Noise* and shall be measured and assessed in accordance with the same standard.
2. Noise generated by the operation of the site shall not exceed the following noise limits at the notional boundary of dwellings existing at the date of this consent (77, 190 and 197 Mairos Road):

Receiver	Noise Limit	
	Monday to Saturday (7:00 am to 9:00 pm) Sunday and public holidays (9:00 am to 5:00 pm)	At all other times
Rural Zone Receivers	55 dB $L_{Aeq,1hr}$	45 dB $L_{Aeq,1hr}$ 75 dB L_{AFmax}

3. Noise levels shall be measured in accordance with the provisions of NZS 6801:2008 *Acoustics - Measurement of environmental sound* and assessed in accordance with the provisions of NZS 6802:2008 *Acoustics - Environmental noise.*

7 Conclusion

SLR has been commissioned to undertake an acoustic assessment of the proposed WtE Facility between Glenavy and the Oceania Dairy Factory in the Waimate District. The proposed facility has been considered with regard to the noise requirements of the Waimate District Council.

Construction generated noise and vibration levels are expected to comply with the limits at surrounding properties due to the distance between the site and receivers.

The predicted noise levels generated by the operation of the proposed WtE Facility (including vehicle noise and train unloading) can comply with the relevant Plan daytime and night-time noise limits at the nearest surrounding noise sensitive dwellings. This assessment includes conservative consideration of special audible characteristics (such as tonal elements) associated with the proposed activities and meteorological effects.

On the basis of the above, the noise effects are considered reasonable with reference to Section 16 of the RMA in terms of the proposed operation, confirming the suitability of the site for the proposed facility.

Appendix A:

Glossary of Acoustic Terminology

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3. Sound Power Level

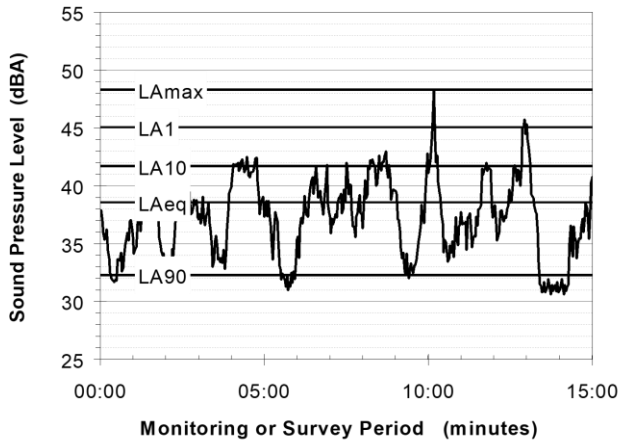
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

5. Frequency Analysis

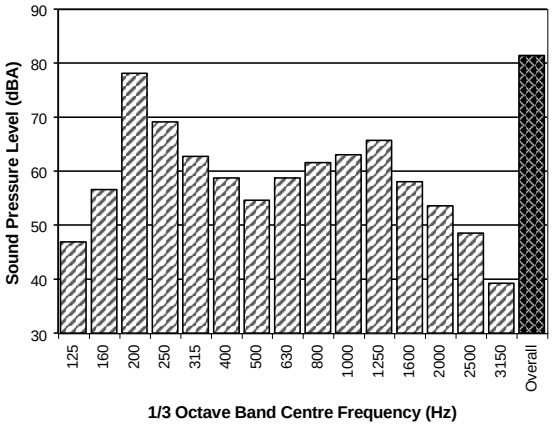
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (three bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (i.e. differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (i.e. vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

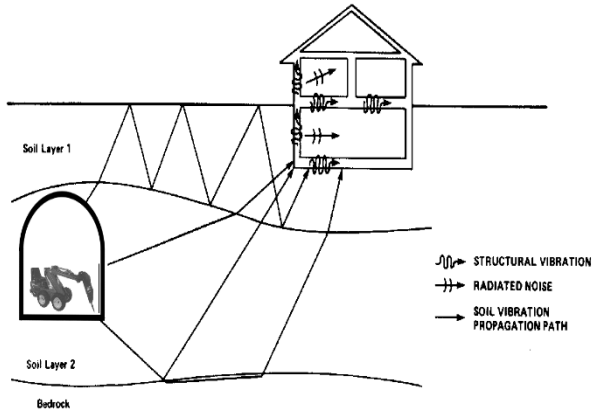
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

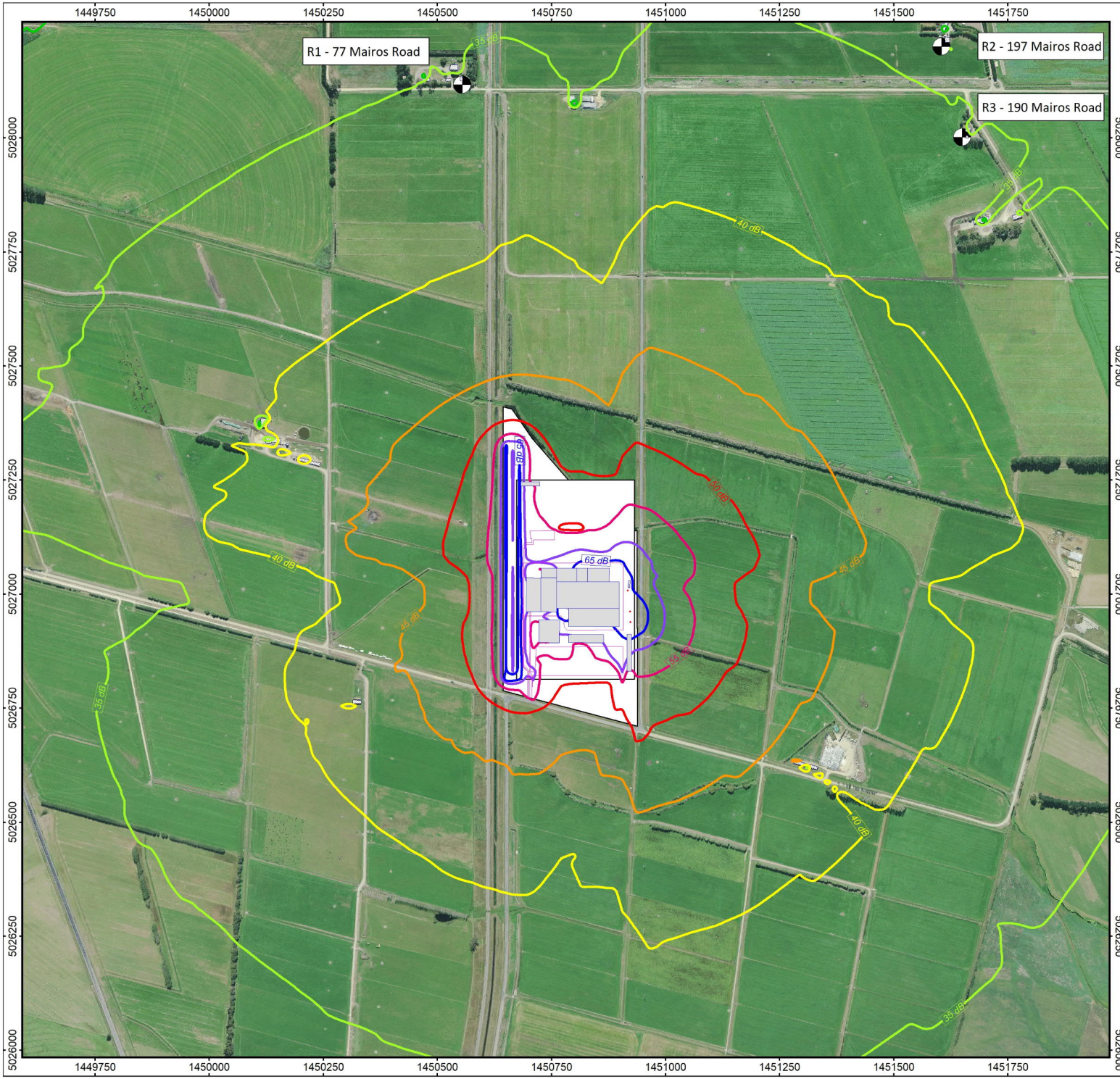
The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

Appendix B:

Noise Level Predictions and Contours – Operations



Customer: South Island Resource Recovery Ltd
Project: Project KEA
Project-No: 710.30307.00200

PROJECT KEA

Map
1

GNM - Operational Noise (Daytime Levels)
Result number 3011
Calculation grid heights 1.8 m above ground

Project engineer: LJ Jansen
Created: 25/08/2022
Processed with SoundPLAN 8.2, Update 2/08/2022

Noise Contours
dB(A) L10

<	30
30 -	35
35 -	40
40 -	45
45 -	50
50 -	55
55 -	60
60 -	65
>=	65

Map Legend
- Buildings
- Calculation Point
- Industrial Building Sou
- Vehilce Movements
- Geometry bitmap

N

Length scale 1:8500
0 50 100 200 300 400 m

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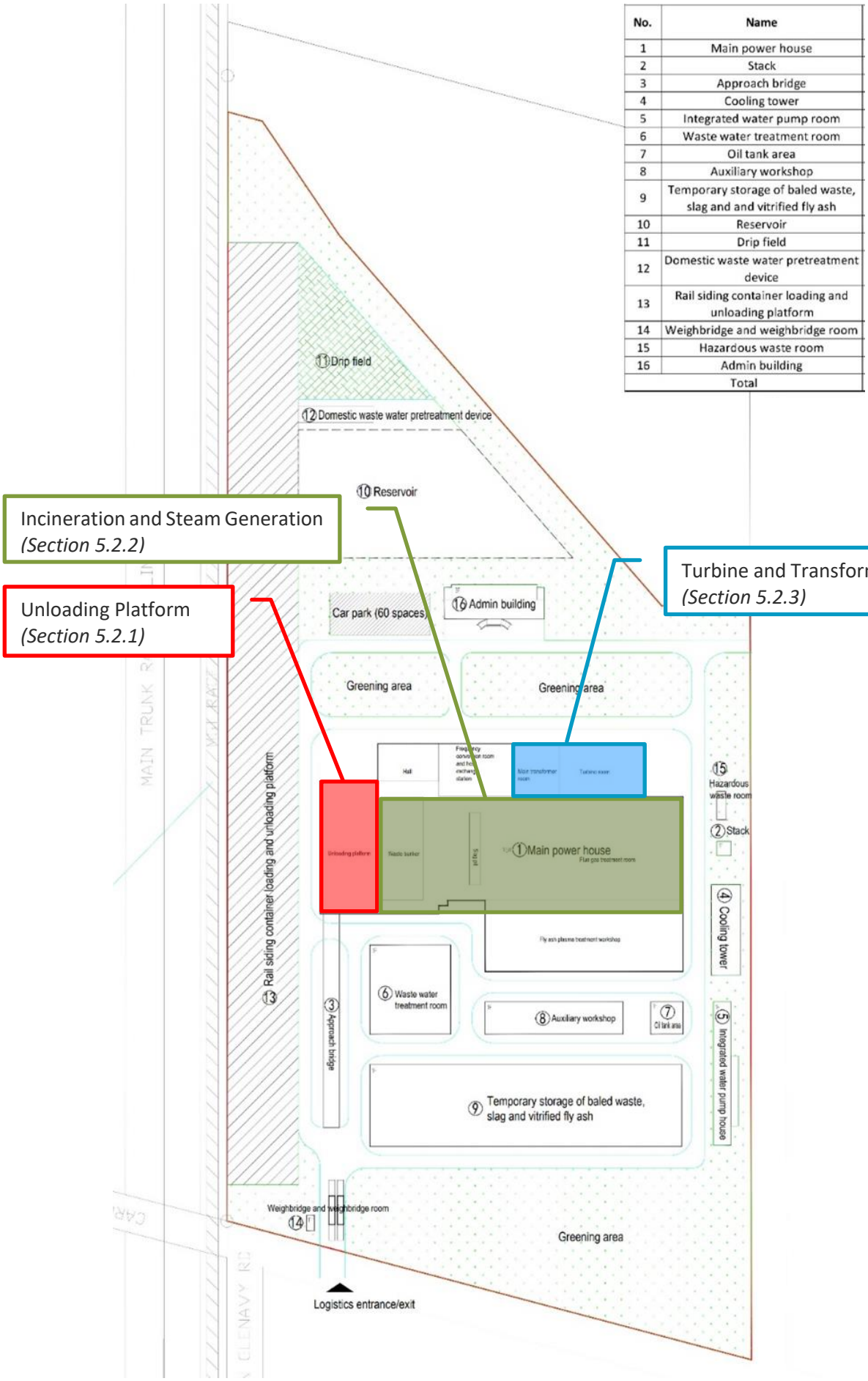
C:\SLR Calculations\Examples and Old Projects\710.30307 - Project KEA (Modelling Data and Information)\SoundPLAN\SP001 v8.2 - Project KEA\S1-Operational.sgs

Appendix C:

Noise Source Map

No.	Name
1	Main power house
2	Stack
3	Approach bridge
4	Cooling tower
5	Integrated water pump room
6	Waste water treatment room
7	Oil tank area
8	Auxiliary workshop
9	Temporary storage of baled waste, slag and and vitrified fly ash
10	Reservoir
11	Drip field
12	Domestic waste water pretreatment device
13	Rail siding container loading and unloading platform
14	Weighbridge and weighbridge room
15	Hazardous waste room
16	Admin building
Total	



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