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Executive Summary

This Environmental Noise and Vibration Assessment investigates the potential noise and vibration impacts of the proposed Chlor-Alkali (chlorine caustic soda) plant at Yarwun, located within the Gladstone State Development Area (GSDA).

The site is located in the MTSC Precinct of the GSDA. There are other existing industrial facilities near the site, including Rio Tinto alumina refinery and consequently industrial noise is a feature of the area. There is eucalypt forest between the industrial uses; forests help to reduce noise by absorption and deflection. There are quarries located to the west of the site on the elevated hills. The nearest residential community, Yarwun Village, is approximately 4.3 km southwest of the site. Yarwun is outside the GSDA. The intertidal area approximately 1.5km to the east has been identified as a possible sensitive receptor and for conservatism has been included in this assessment. Background noise levels at night in Yarwun Village are estimated at 30 dB(A), consistent with a rural community.

Noise emissions from the development are predominantly continuous noise from pumps, electric motors, and process equipment. Other noises include occasional heavy vehicle noise, front-end loader operations and potentially low-frequency noise from chlorine compressors. The project design has the compressors located in a building specially designed to limit noise emissions.

The environmental values to be preserved comprise:

- (a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and
- (b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following-
 - a. sleep;
 - b. study or learn;
 - c. be involved in recreation, including relaxation and conversation; and
- (c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

Goals developed for this project address:

- preserving sleep quality;
- ability communicate;
- avoiding low-frequency noise impacts;
- maintaining the rural noise landscape at Yarwun Village; and,
- avoiding flight responses for shorebirds in the intertidal area.

Noise modelling was conducted using PEN3D software, incorporating terrain data, meteorological conditions, and conservative assumptions about sound power levels. Noise levels at Yarwun Village are predicted to be well below the noise level goals during all time periods (day, evening, and night). Noise levels in the intertidal area are expected to remain below 45 dB(A), which is unlikely to disturb shorebirds.

The proposed Chlor-Alkali plant is anticipated to have negligible noise and vibration impacts on Yarwun Village and the intertidal area. The project aligns with the GSDA Development Scheme and Environmental Protection (Noise) Policy 2019, preserving the acoustic environment and ensuring no adverse effects on sensitive receptors or ecosystems.

1 Introduction

Simpson Engineering has been retained by CQG on behalf of Grenof Water Technologies Pty Ltd (the proponent) to undertake a noise and vibration assessment of a proposed Chlor-Alkali (chlorine caustic soda) plant located in Yarwun, north of Gladstone.

Simpson Engineering Group is a consulting engineering group specialising in noise, vibration, lighting and air quality assessments.

1.1 Site

The site is situated in the Gladstone State Development Area (GSDA) comprising a portion of Lot 1 on MPH 32292 (56 Fisherman's Road Yarwun) and Lot 1 on SP200899 (26 Landing Road Yarwun), refer to Figure 1. There are numerous industrial uses nearby including:

- Rio Tinto Alumina Refinery;
- Cement Australia Fishermans Landing Plant;
- Northern Oil Refinery;
- Cleanaway Industrial Waste Services;
- Butlers Yarwun Quarries; and,
- Queensland Energy Resources.

The site is situated within the Materials Transportation and Services Corridor (MTSC) Precinct of the GSDA, with Port Related Industry Precinct and Industry Investigation Precincts nearby. The location is close to the western basin of Gladstone Harbour, approximately 1500m to the intertidal zone.

The site and surroundings comprise several industrial uses interspersed with subtropical eucalypt forest and woodland.

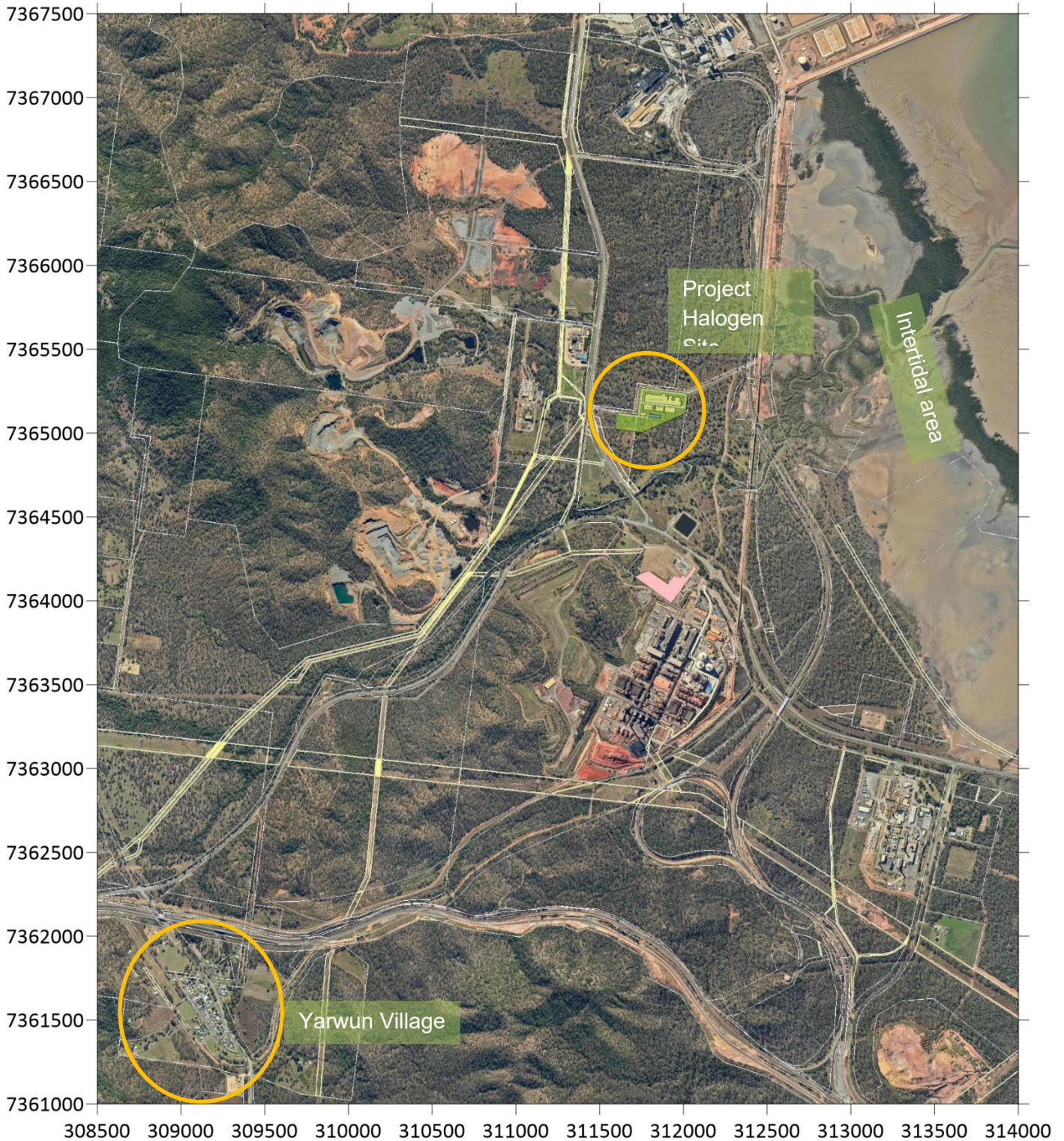


Figure 1: Site and Surroundings

1.2 Process Description

The chlor-alkali process is an industrial chemical process used to produce chlorine gas (Cl_2), sodium hydroxide (NaOH), and hydrogen gas (H_2) from the electrolysis of salt water (sodium chloride, NaCl). The chlor-alkali production facility will also produce derivative chemicals from the primary products, which include sodium hypochlorite and hydrochloric acid. Apart from the loading of salt by front end loader, the entire process comprises continuous operation chemical processing plant.

From a noise perspective the noise generated by the site comprises:

- Occasional heavy vehicle noise associated with the delivery and export of materials
- Front-end loader noise associated with salt materials handling
- Continuous noise associated with pumps, electric motors and process equipment.
- Potentially low frequency noise elements associated with the chlorine compressors.

No blasting is proposed for the project. The operational facility equipment as described above does not generate significant vibration. Consequently, vibration is not discussed further in this report.

1.3 Noise Sensitive Receptors

Approximately 4.3km to the southwest is the village of Yarwun, the closest residential community, refer to Figure 1. This community is not within the GSDA. Yarwun village is adjacent to the railway and Earth Commodities Quarry. The railway connects to the Blackwater Rail System and the Moura Rail System with annual exports through the Port of Gladstone of approximately 50 MTPA requiring about 24 train passes daily. Other rail traffic includes containerised freight and passenger trains.

A noise survey has not been undertaken in Yarwun for this project. It is assumed that the rating background noise level at night is likely to be approximately 30 dB(A), i.e. a noise level consistent with a rural community with low-level contributions from industrial and transportation noise, refer to AS1055.3 1997 Appendix A: Estimated average background a-weighted sound pressure levels (LA90,t) for different areas containing residences in Australia.

The ambient noise of the intertidal area to the east of the site is likely to be influenced by shipping noise and nearby industrial noise. The ambient noise level is also likely to be approximately 30 dB(A).

2 Noise Level Goals

2.1 Gladstone Regional Council

Since the site is situated in GSDA, material change of use (MCU) applications are administered by the Coordinator-General through the GSDA Development Scheme.

2.2 GSDA Development Scheme

The GSDA Development Scheme has been prepared pursuant to sections 79 to 80 of the SDPWO Act and takes effect on the date stated in the gazette notice published under section 80(1)(a) of the SDPWO Act. The scheme contains the following with respect noise and vibration impacts.

2.5.3 Environmental nuisance

1. Development is located, designed, and operated to avoid, minimise or manage:
 - a. adverse impacts from air, noise and other emissions that will affect the environment and/or health and safety, wellbeing, and amenity of communities and individuals
 - b. conflicts with sensitive uses arising from (but not limited to) spray drift, odour, noise, light spill, dust, smoke, or ash emissions.
2. The location, design and operation of development achieves the relevant acoustic objectives of the Environmental Protection (Noise) Policy 2019 and achieves the relevant air quality objectives of the Environmental Protection (Air) Policy 2019.
3. Development:
 - a. avoids adverse impacts on the cumulative air quality of the Gladstone airshed or
 - b. where impacts cannot be avoided, conducts air shed modelling in accordance with current best practice to demonstrate compliance with air quality standards.

2.3 State Code 22 – Environmentally Relevant Activities

The purpose of the code is to ensure that environmentally relevant activities (ERAs) as described under Schedule 2 of the Environmental Protection Regulation 2019:

1. are located and designed to avoid or mitigate environmental harm on environmental values of the natural environment, adjacent sensitive land uses and sensitive receptors;
2. are designed and located to avoid impacts or, where the matters of state environmental significance cannot be reasonably avoided, impacts are reasonably minimised and mitigated;
3. does not result in a significant residual impact on a matter of state environmental significance unless the significant residual impact is acceptable, and an offset is provided.

The performance outcomes and acceptable outcomes with respect to noise is contained in Table 1.

Table 1: Performance and Acceptable Outcome

Performance Outcome	Acceptable Outcome
PO1 Development is suitably located and designed to avoid or mitigate environmental harm to the acoustic environment.	AO1.1 Development meets the acoustic quality objectives for sensitive receptors identified in the Environmental Protection (Noise) Policy 2019.

2.3.1 ESR/2015/1838

The Guideline ESR/2015/1838 describes types of impacts that ERA's can have in relation to noise and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving acoustic environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values

It is necessary to identify the environmental values of the site including but not limited to:

1. Identify sensitive places
2. Provide a site description.
3. Provide details of a background noise survey.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify all noise, vibration, and air blast overpressure sources, including stationary and mobile sources, associated with the activity. Also provide a scaled map which shows the source of all noise emissions in relation to any existing noise sensitive places
2. Describe in detail, the characteristics of the noise emissions produced.
3. Describe how noise, vibration or airblast overpressure emissions will be avoided, minimised or otherwise managed in accordance with the noise management hierarchy provided in the EPP (Noise).

If it is not possible to mitigate the impacts associated with the noise emission, applicants are to provide a noise impact assessment, which identifies the likely effect of noise from the activity on nearby sensitive places and include:

- Noise modelling contour maps to show predicted noise levels at all potential noise source locations.
- Analysis on whether noise emissions associated with the activity will adversely affect the environmental values of the receiving environment (including noise sensitive places).
- Description of controls (e.g. noise emission limits or operational controls such as operating hours) which are appropriate to protect environmental values.
- A vibration risk assessment for blasting activities, if applicable.
- If blasting is to occur, that blasting activities will be managed in accordance with AS 2187: Explosives.

Due to the rapid growth and increasing density of noise-producing activities in Queensland, the consideration of cumulative noise impacts and background creep is particularly important. For applications where background creep is likely, applicants are encouraged to use modelling to demonstrate that the activity will, to the extent it is reasonable to do so, ensure that background creep in an area or place is prevented or

minimised. If the acoustic quality objectives for an area or place are not being achieved or maintained, the noise experienced in the area or place must, to the extent it is reasonable to do so, be dealt with in a way that progressively improves the acoustic environment of the area or place.

2.4 Environmental Protection Act 1994

The objective of the EP Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

The EP Act states a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. This is termed the 'general environmental duty'.

Environmental harm is defined as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance.

The noise level goals for operations may be determined from the *Environmental Protection (Noise) Policy 2019* (EPP (Noise)). The EPP (Noise) came into effect on 1 Sept 2019.

The purpose of the EPP(Noise) is to achieve the objects of the Act and achieved by:

- a) identifying and declaring the environmental values of the acoustic environment; and
- a) stating acoustic quality objectives that are directed at enhancing or protecting the environmental values; and
- b) providing a framework for making consistent, equitable and informed decisions that relate to the acoustic environment.

The environmental values to be enhanced or protected under the EPP(Noise) are:

- (d) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and
- (e) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following-
 - a. sleep;
 - b. study or learn;
 - c. be involved in recreation, including relaxation and conversation; and
- (f) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

There are two main considerations namely:

1. Acoustic quality objective (noise levels that are conducive to human health and well-being, ensuring a suitable acoustic environment for individuals to sleep, study or learn, be involved in recreation, including relaxation and conversation; and preserve the qualities of the acoustic environment that are conducive to protecting the amenity of the community); and
2. Management Intent

2.4.1 Acoustic Quality Objectives

The 'Acoustic Quality Objectives' described in the EPP(Noise) seek to protect the amenity of an acoustic environment. The indoor night-time goals effectively address sleep disturbance and sleep awakenings, while

during the day it protects conversation. It should be noted that these are not strictly design limits for individual sources but objectives that are considered to provide acceptable health and wellbeing for the community.

The acoustic quality objectives are expressed as indoor noise level goals for dwellings at Night (10 pm to 7 am) and outdoor noise level goals during the Day (7 am to 6 pm) and Evening (6 pm to 10 pm). These objectives are all contained in Table 2.

The equivalent external noise levels (for the dwelling indoor noise level goals in Table 2) measured at least 4 m from the dwelling would be 7 dB higher (to allow for the reduction of noise through the building envelope) for windows wide open, see “Noise and vibration EIS information guideline” dated 2024 by Department of Environment, Science and Innovation. If windows are closed the external noise goals would be 15 dB(A) higher than the internal noise level goals, see Australian Department of Health enHealth Guideline, “The health effects of environmental noise” dated 2018 for the windows closed noise reduction.

Table 2: Acoustic Quality Objectives for Dwellings and Other Receivers Relevant to the Project during the Day (7 am to 6 pm), Evening (6 pm to 10 pm) and Night (10 pm to 7 am).

Location	Time of Day	Acoustic Quality Objectives (Measured at the receptors) dB(A)			Environmental Value
		L _{Aeq} , adj, 1 hr	L _{A10} , adj, 1 hr	L _{A1} , adj, 1 hr	
Dwelling outdoors	Daytime & evening	50	55	65	Health and wellbeing
Dwelling indoors	Daytime & evening	35	40	45	Health and wellbeing
Dwelling indoors	Night-time	30	35	40	Health and wellbeing, in relation to the ability to sleep
Protected area or critical area	anytime	The level of noise that preserves the amenity of the existing area or place			Health and biodiversity of ecosystems

Source: EPP (Noise)

2.4.2 Managing Intent For Noise

It is intended that noise from an activity that affects or may affect an environmental value to be enhanced or protected under the EPP(Noise) be appropriately managed.

To the extent it is reasonable to do so, noise must be dealt with in a way that ensures-

- a) the noise does not have any adverse effect, or potential adverse effect, on an environmental value under this policy; and
- b) background creep in an area or place is prevented or minimised.

In the situation where existing noise levels exceed the Acoustic Quality objectives, to the extent it is reasonable to do so, noise at that sensitive place must be dealt with in a way that progressively improves the acoustic environment of the area or place.

Background creep, for noise in an area or place, is described as a gradual increase in the total amount of background noise in the area or place.

The EPP(Noise) does not provide any guidance nor limits regarding how to address background creep.

However, the guiding principles are:

- i. Background creep in an area is to be prevented or minimised
- ii. Any control requirements are to be reasonable

Background creep can be prevented by ensuring the noise from activity is always below the background noise level. However, this may be excessively onerous for many situations. The EPP(Noise) does not include any guidance regarding how to assess “reasonable” noise control. A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves making a judgement to determine whether the overall noise-reduction benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the noise abatement measure. To make such a judgement, consideration may be given to aspects such as noise level impacts, noise mitigation benefits, cost effectiveness and community views.

2.5 Sleep Disturbance WHO Guidelines

Research has shown that the ability to get to sleep and, when asleep, the probability of experiencing a change of sleep state or ultimately of awakening are related to both the ambient and maximum instantaneous noise levels at the ear of the sleeper and the number of events during the night period (WHO 1999).

As a rule in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45dBA maxLpA more than 10-15 times per night. According to the withdrawn Guideline Ecoaccess Planning for Noise Control (EPA 2004), the corresponding external noise level, assuming partially closed windows, is 52dB(A) maxLpA (L_{Amax}), measured in the free field. With fully closed windows the corresponding external noise level is 60dB(A) maxLpA (L_{Amax}). Although now withdrawn, the sleep disturbance approach and calculation methodology in the guideline are still recognised (e.g., in the Model Mining Conditions ESR/2016/1936, last revised 19 February 2024)

For larger number of events per night, the noise level goal is reduced by $10 \cdot \log(\text{Number of events}/10)$. Hence if there are 100 events per night (over an 8-hour period) the external noise level goal would 10 dB(A) lower than that described above.

2.6 Low Frequency Noise

There are not any current Queensland guidelines dealing with low frequency noise. Recognised noise criteria for low frequency noise are provided in the withdrawn DEHP Ecoaccess Draft Guideline “Assessment of Low Frequency Noise” identifies a number of industrial sources and processes having high noise levels and frequency content less than 200 Hz.

Industrial sources may exhibit a spectrum that characteristically shows a general increase in sound pressure level with decrease in frequency. Annoyance due to low frequency noise can be high, even though the dB(A) level measured is relatively low. Typically, annoyance is experienced in the otherwise quiet environs of residences, offices and factories adjacent to, or near, low frequency noise sources. Generally, low level/low frequency noises become annoying when the masking effect of higher frequencies is absent. This loss of high frequency components may occur as a result of transmission through the fabric of a building, or in propagation over long distances.

Where a noise emission occurs exhibiting an unbalanced frequency spectra, the overall sound pressure level inside residences should not exceed 50 dB(Linear) to avoid complaints of low frequency noise annoyance.

2.7 Road Traffic Noise Goals

Queensland Department of Transport and Main Roads (DTMR) is responsible for setting noise level limits from road traffic on public roads in Queensland. Typically, the planning goals for roads are met close to the road, i.e. distances up to about 30 m or thereabouts. There are no criteria in Queensland to assess the impact of noise from a road traffic-generating development. However, for existing roads with regular traffic an

increase of 3 dB(A) over a short period of time is considered to be a significant increase in traffic noise and an increase which justifies consideration of noise control.

Since the hourly traffic to and from the site is minor, road traffic impacts on public roads will not be considered further.

2.8 Intertidal Areas

Smit, C. J. and Visser, G. J. (1993) Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area (Wader Study Group Bulletin 68: 6-19) found that an L_{Amax} of 55 dB(A) did not have adverse impacts on roosting waders. Consequently, an L_{Amax} of 55 dB(A) would be an appropriate noise level goal for the intertidal area.

2.9 Summary of Noise Goals

The site is situated in the GSDA area and within the MTSC precinct. The nearby areas contain several very large industrial developments and by comparison this is a modest sized project with low-level continuous noise emissions. The focus of the goals is to ensure that the noise levels do not lead to a deterioration of the noise environment at noise sensitive receptors. Additionally, the preservation of sleep and avoiding low-frequency impacts are important considerations. Traffic from the site will not pass any sensitive receptors prior to combining with existing traffic on Gladstone Mt Larcom Road, a major road traffic arterial route into Gladstone. Consequently, road traffic noise is not considered further in this report.

The development will seek to meet noise level goals at Yarwun Village and ensure other future industrial uses in the GSDA are not compromised by noise emissions from the project.

Application of GSDA Noise Policy

The GSDA has indicated that the noise limits for industrial developments are to comply with acoustic objectives of the EPP (Noise).

Application of State Code 22

The state code requires the indoor noise objectives set out in the EPP (Noise) to be met. This ensures the ability to sleep and converse while inside a residence.

Application of the EP Act and EPP(Noise)

The EP Act provides the framework for all noise impacts. Apart from some selected noise sources, the Act and the EPP(Noise) does not provide source limits for industrial developments, rather it provides noise quality objectives to be met in Queensland, ensuring the quality of the environment does not deteriorate. In this instance the State Code 22/ ESR/2015/1838 indicates the indoor quality objectives are to be used as limits for the development. As discussed in Section 2.4.1 an external noise level goal may be obtained by adding 7 dB(A) to the indoor noise level goal, being the noise reduction from outside to inside assuming wide open windows. Equivalent external noise level goals are more convenient for reporting and comparison purposes.

Application of Low Frequency Noise Goals

It is possible that, due to the propagation of noise over the large separation distances between the source of noise and the receiver, a loss of high frequency components may occur. Thus, the low frequency noise goal of 50 dB(Linear) applies inside noise sensitive receptors. The same 7 dB reduction from outside to inside applies (for partially open windows), i.e. the equivalent external noise is 57 dB(Linear).

Application of WHO Sleep Disturbance Guidelines

It is proposed to adopt an L_{Amax} of 52dB(A) (outside dwellings) as the appropriate noise level goal to protect sleep disturbance.

A summary of the noise goals for this project is contained in Table 3. The limits are component levels, i.e. directly attributable to the use (modelled noise levels), rather than measured levels. Measured noise levels include background and other noise sources.

Table 3: Summary of Component Noise Goals (free-field)

Location	Time Period	$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A10, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]	$L_{Amax, adj, 1 hr}$ [dB(A)] Sleep disturbance	Low Frequency $L_{eq, adj, 1 hr}$ [dB]
All Residential Receptors	Day	42	47	52	-	-
	Evening	42	47	52	-	-
	Night	37	42	47	52	57

3 Predicted Noise Levels

3.1 Modelling Methodology

A digital terrain noise model of the site and surroundings has been developed using PEN3D software. The PEN3D General Prediction Model (GPM) is based on the method contained in a book by Bies and Hansen (1988, pages 117, 127). The implementation is a more complex and sophisticated variation of the approach to sound propagation described in Concawe (1981). Concawe is one of the most commonly used methodologies to predict outdoor noise propagation from industrial sites. PEN3D also draws on aspects from ISO 9613-2. The PEN3D software was originally developed in 1993 and has been in constant development and review. The basic equation adopted by the GPM is:

$$L_p = L_w - 20 \log_{10}(r) - 10 \log_{10}(4\pi) + AE$$

Where:

L_p is the sound pressure level at an observer

L_w is the sound power level of the source, in octave bands from 63 Hz to 8 kHz

$20 \log_{10}(r) + 10 \log_{10}(4\pi)$ is the distance attenuation (spherical)

AE is the excess attenuation factors.

The excess attenuation factors AE comprise:

$$AE = A_a + A_g + A_m + A_b + A_f$$

Where:

A_a = Excess attenuation due to air absorption from Sutherland *et. al.* (1974)

A_g = Excess attenuation due to ground reflection

A_m = Excess attenuation due to meteorological effects

A_b = Excess attenuation due to barriers

A_f = Excess attenuation due to forests.

PEN3D is a sophisticated environmental noise model incorporating a 3D terrain model that permits accurate representation of the ground, ground cover, tree zones, mounds, barriers and weather conditions. PEN3D calculates a curved noise path based on surface friction, vertical temperature gradients and wind speed. All the noise calculations are based on this curved path. A finite differences approximation method is used to calculate the curved path. The curvature of the path determines the meteorology corrections. The meteorology corrections are frequency and distance dependent and are limited to +12 dB (downwind at night) and -7 dB (upwind and during the day) similar to the Concawe Category 1 and Category 6 meteorological corrections.

The excess attenuation due to ground reflection is obtained by combining the direct wave and the reflected wave incoherently, that is the energy from the ground wave is added to the direct wave. The ground reflection attenuation (or ground effects) will be between 0 and -3 dB (a negative value is an increase in noise levels) for all cases. This contrasts with the coherent reflection approach. The coherent approach is considered to be an "exact" method. For those situations where the source and receiver are located close to the same very hard reflecting plane and the path difference between the direct path and the reflected path is small, then the

addition of the reflected wave and the direct wave will result in 6 dB increase rather than a 3 dB increase. However, at large distances the sound pressure level reduces at 12 dB per doubling with the coherent model (not 6 dB as per the incoherent model). This approach, while “exact”, is dubious as Digital Terrain Models (DTM) models are neither of sufficient accuracy nor can noise models truly account for the effects of atmospheric turbulence. Other methods such as the Nordic method or ISO 9613-2 divide the region between the source and receiver into three zones, and those zones closest to the source and to the receiver can potentially have higher absorption values. Consequently, if a noise source was measured say at a distance of 30 m and the sound power level is calculated by the commonly adopted formula $PWL = SPL + 10\log_{10}(2\pi r^2)$ then the calculations using the PEN3D methodology would remain conservatively high for all distances.

The ground reflection (or ground effects) is a complex calculation using the flow resistivity for the surface likely to provide the ground reflection and the likely angle of incidence of the reflected wave to the ground. In those instances where the ground is highly absorptive the excess correction will approach zero. For those surfaces which are highly reflective the correction will be - 3dB, i.e. will lead to an increase in noise levels of 3 dB(A) (simulates hemispherical propagation).

While there are numerous methods to calculate ground effects (some of which provide significant attenuation [reduction of noise levels]), the PEN3D implementation is one of the more conservative estimates of ground effect in the far field. Bies & Hansen (1988) indicate “as the distance from the source or frequency increases, the incoherent model will become more appropriate”.

The theoretical approach to meteorology implies that PEN3D is likely to provide more significant corrections than other models. Thus, at night or during downwind predictions, the PEN3D calculations are likely to result in conservatively high results, i.e. the modelled noise levels are likely to be higher than the measured levels.

The likely barrier attenuations are calculated for four possible curved paths, namely:

- source, to the top of barrier then to the receiver;
- source, reflection from ground (source side), top of barrier, receiver;
- source, top of barrier, reflection from ground (receiver side), receiver; and
- source, reflection from ground (source side), top of barrier, reflection from ground (receiver side), receiver.

These are combined to obtain effective barrier attenuation. In the situation where the source and receiver are well above the ground and the barrier just intercepts line-of-sight then the barrier effect will be 5 dB(A). However, if the source and receiver are close to the ground and the noise barrier just intercepts line of sight (a pebble) the barrier effect will tend to zero.

Once the most likely curved path has been calculated, the method determines if it intercepts any tree zones within the digital terrain model. If the curved noise path travels in the lower 75% of the tree zone then the full excess attenuation is applied for the distance travelled through the tree zone. If the curved noise path travels in the upper 25% of the tree zone then:

- a) the average propagation height is determined;
- b) the length in the zone is determined; and,
- c) the forest excess attenuation is taken to be linearly interpolated between zero at the top of the tree zone and full excess attenuation at 75% height.

Tree zones can potentially provide extremely high attenuation if the tree coverage is large. However, in practice, the curved path adopted in the PEN3D methodology usually results in the noise rays passing above tree zones (at night or during downwind conditions) and only intercepting tree zones if they exist on the tops of hills or whenever the noise ray approaches the ground.

3.2 Meteorology

The meteorology for the site has been analysed to address frequent wind speeds, wind directions and inversions.

3.2.1 Temperature Inversions

The total night-time period during winter (June, July and August) has been analysed to determine the frequency of inversions, as presented in Table 4. Temperature inversions generally occur during the night-time and early morning periods. The likelihood of inversions reduces with wind speed. It was determined that inversions are likely about 90% of the time since calm winds are common at night. This indicates that modelling during inversion conditions is appropriate. The wind direction analysis confirmed that the light winds at night are dominantly from the south-east.

It is proposed to model inversions with the following parameters:

- 2 degrees Celsius (°C)/100 m temperature inversion strength.
- Zero wind speed, 2m/s from the southeast and 2m/s from the west.
- Air temperature 15°C.

Table 4: Wind Speed Analysis For Inversions June to August (6 pm to 7 am)

Wind speeds	Percentage of Time Occurring (%)
Calms	56
Winds less than 1m/s	31
Wind 1 to 2 m/s	3
Wind 2 to 3 m/s	0
Wind 3 to 4 m/s	0
Wind 4 to 5 m/s	0

3.2.2 Wind Effects

Wind effects are typically assessed when wind is a feature of the area. Wind is a feature when source-to-receiver wind speeds (at 10 m height) of 3 m/s or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season. This differs from the procedure used with temperature inversions, in that the 30 percent occurrence applies to all seasons and each assessment period—and not just the winter season and night/early morning assessment period. Refer to Table 5 for an analysis of the winds. It is evident that winds from the SE are dominant during the evening and at night throughout the year. However during the day the SE winds do not reach the 30% threshold, however it does when the adjoining SSE direction is included.

Table 5: Wind Speed and Wind Direction Analysis for Winds 0.5m/s to 3m/s

Direction	Day				Evening				Night			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
N	7%	2%	5%	5%	10%	3%	2%	9%	3%	1%	0%	1%
NNE	4%	2%	3%	7%	9%	3%	3%	11%	1%	0%	0%	2%
NE	3%	3%	2%	9%	4%	3%	2%	7%	1%	0%	0%	1%
ENE	21%	16%	17%	22%	11%	6%	1%	9%	2%	0%	0%	3%
E	26%	24%	21%	35%	18%	7%	4%	23%	3%	0%	0%	7%
ESE	12%	11%	13%	8%	20%	11%	16%	23%	5%	1%	2%	6%
SE	9%	8%	6%	4%	13%	15%	19%	7%	15%	4%	6%	13%
SSE	4%	8%	6%	2%	5%	9%	8%	1%	27%	21%	21%	18%
S	1%	2%	2%	0%	1%	1%	1%	0%	2%	4%	3%	2%
SSW	1%	2%	1%	0%	1%	1%	1%	0%	1%	3%	3%	2%
SW	1%	4%	4%	1%	0%	4%	2%	1%	3%	3%	3%	2%
WSW	2%	6%	5%	1%	1%	2%	2%	1%	5%	13%	10%	4%
W	2%	7%	8%	1%	1%	4%	4%	1%	12%	29%	31%	15%
WNW	1%	2%	3%	1%	2%	23%	24%	4%	9%	15%	16%	18%
NW	4%	1%	1%	1%	1%	7%	8%	2%	5%	3%	5%	5%
NNW	3%	2%	2%	2%	5%	2%	4%	2%	5%	1%	0%	2%

The wind direction and wind speeds were analysed to determine whether wind effects need to be considered. For this analysis, the wind speed was limited to 3 m/s since higher wind speeds tend to increase the ambient noise.

The modelling cases adopted in Table 6 are based on the wind distribution. For this project, there are three night cases to consider. The first being the most common no-wind case. The remaining two options being with a south-east breeze and a land breeze from the west.

Table 6: Meteorology Modelling Cases Assessed

Case	Percentage of time Case Occurs	Wind speed [m/s]	Wind Direction [degrees from North]	Vertical Temp Profile [°C/100 m]	Air Temp [°C]
Day	51% to 65%	2	90	-2	25
Evening	31% to 43%	2	135	0	20
Night (Inversion no wind)	38% to 48%	0	0	2	10
Night (inversion with SE wind)	13% to 19%	2	160	2	10
Night (inversion with land wind)	11% to 56%	2	270	2	10

3.3 Noise Model Parameters

The DTM for the site and surrounds was obtained from LIDAR obtained from Elvis - Elevation and Depth - Foundation Spatial Data <https://elevation.fsdf.org.au/> It was contoured to 1m intervals. The noise model has an adopted ground cover of 'thick grass' as a representation of the combination of the roughness provided by pasture and the taller vegetation that exists throughout the region. The model does not incorporate excess attenuation factors associated with tree zones.

The $L_{Aeq(60 \text{ min})}$ equipment noise levels are contained in Table 8. The noise levels are expressed as a sound power level. The overall sound power levels are "A" weighted. The "A" weighting emulates the way the human ear responds to sound.

The proponent has not provided any noise levels for the industrial plant. However, the proponent has supplied a typical list of the mechanical plant likely to operate at the plant. These noise sources include:

- Electric motors;
- Liquid pumps;
- Fans;
- Blower (emergency exhaustor);
- Shaft gear reducers;
- Chlorine compressors (in a compressor building); and,
- a front-end loader.

There is insufficient information in the documentation to determine the sound power level for the individual items of process plant. However, the specification includes an occupational noise level commitment that a noise level of 85 dB(A) at 1m will be met from all plant and equipment. Thus, staff will not be required to wear hearing protection unless working within 1m of process plant.

For the purposes of determining sound power level from all plant, the enclosing areas 1m from all machinery and assuming a height of 2m has been calculated the enclosing area is 1,500m² and assuming the noise level is 85 dB(A) at the surface of the enclosing area the sound power level would be 116 dB(A). Since the most common noise sources are pumps and electric motors then it is proposed to adopt the spectra typically associated with electric motors, refer to Table 7.

Table 7: Sound Power Correction for Electric Motors and Pumps (Source US army)

Noise Source	Value to be subtracted from overall level dB in Octave band centre frequency (Hz)						
	63	125	250	500	1000	2000	4000
Pumps	12	11	9	9	6	9	13
Electric motors	9	7	7	6	9	12	18

Hence the total sound power level for the process plant and the front-end loader is contained in Table 8. The noise sources are positioned 3.0m above the local terrain. It should be noted that the spectra for the process plant are heavily biased towards the low frequency. This implies that barrier screening effects and air absorption will be low compared with noise containing more high frequency components.

Table 8: Sound Power Levels ($L_{Aeq(1 \text{ hr})}$) in dB(A) for plant

Noise Source	Sound Power Level in dB in Octave band centre frequency (Hz)

	63	125	250	500	1000	2000	4000	8000
Process Plant	141	133	126	121	115	111	105	98
Front End Loader	104	109	95	91	101	88	83	73

3.4 Noise Modelling Results

A single noise case has been developed for the project involving the continuous process plant. A series of noise models was developed for each of the various meteorological cases.

Table 9 and Table 10 contains the calculated $L_{Aeq(1\text{ hour})}$ noise levels at the sensitive receptors (Yarwun Village and intertidal area respectively) for all modelling cases in tabular format, Appendix A contains the noise contour diagrams. The results are summarised for the day, evening and night periods.

Table 9: Calculated Noise Levels - Yarwun Village

Location	Time Period	$L_{Aeq, adj, 1\text{ hr}}$ [dB(A)]	$L_{A10, adj, 1\text{ hr}}$ [dB(A)]	$L_{A01, adj, 1\text{ hr}}$ [dB(A)]	$L_{Amax, adj, 1\text{ hr}}$ [dB(A)] Sleep disturbance	Low Frequency $L_{eq, adj, 1\text{ hr}}$ [dB]
Noise Level Goals	Day	42	47	52	-	-
	Evening	42	47	52	-	-
	Night	37	42	47	52	57
Predicted Noise Levels Yarwun Village	Day	23	25	26		
	Evening	12	14	15		
	Night No wind	26	28	29	30	49
	Night SE Wind	12	14	15	16	36
	Night West Wind	13	15	16	16	35

Table 10: Calculated Noise Levels – Intertidal Area

Location	Time Period	<i>L</i>_{Amax, adj, 1 hr} [dB(A)] Shorebird No Response
Noise Level Goal	All Hours	55
Predicted Noise Levels in the intertidal area	Modelling Case	-
	Day	35 to 45
	Evening	35 to 45
	Night No wind	35 to 45
	Night SE Wind	35 to 45
	Night West Wind	38 to 45

4 Assessment of Modelled Noise Levels

Operational Noise Assessment

The noise from the operation of the processing plant is expected to readily comply with the noise level goals at Yarwun Village during all time periods. Indeed, the predicted noise levels are likely to be below the existing background noise levels in Yarwun Village.

It is evident from the noise contours that the ridge running north-south adjacent to the site to the west, provides screening of noise towards the west. The contours to the north and east are not significantly screened by terrain. The noise levels at the intertidal area is likely to be below 45 dB(A). Since the noise is continuous in nature it is unlikely to cause any responses by shorebirds in the intertidal areas.

5 Conclusions

The noise investigation of the proposed Chlor-Alkali (chlorine caustic soda) plant to be located in Yarwun has been based on a conservative modelling methodology.

Initially the meteorology for the site was assessed in detail to determine whether inversions and/or winds were likely to be frequent for the site. It was determined that inversions are frequent in winter. Assessment of wind occurrence indicated that winds occur during the all times of the day, evening and night largely due to it's near coastal location.

The likely noise levels from operating equipment have been robustly established based occupational noise commitments and knowledge of the dominant types of noise sources. It should be noted that the frequency spectra for the process plant are heavily biased towards the low frequency noise components. This implies that barrier screening effects and air absorption will be low compared with noise sources having relatively more high frequency components. It is likely the sound power estimate from the process plant has been substantially overestimated using the occupational noise level limit for all plant. Many items of plant will be much lower than the occupational noise level limit at 1m from the unit.

The digital terrain model has been based on Lidar data from the public domain. The adoption of these contour levels would provide the major features without over emphasising possible noise screening effects of smaller landforms.

A noise survey was not undertaken in this instance. It has been conservatively assumed that the rating background noise level at night is likely to be approximately 30 dB(A), i.e. a noise level consistent with a rural community with low-level contributions from industrial and transportation noise. It is considered important to retain the rural noise landscape at Yarwun Village as far as possible and comply with noise level goals.

The noise level goals applicable to the site have been reviewed. The site is situated in the GSDA and within the MTSC Precinct. The nearby areas contain several very large industrial developments and by comparison this is a modest sized project having a mostly low-level continuous noise emissions. Hence the focus of the noise level goals is to ensure that the noise levels do not lead to a deterioration of the noise environment at noise sensitive receptors. Additionally, the preservation of sleep and avoiding low-frequency impacts are important considerations. Since traffic from the site will not pass any sensitive receptors prior to combining with existing traffic on Gladstone Mt Larcom Road, road traffic noise was not assessed.

It was determined that noise from the operation of the proposed Chlor-Alkali (chlorine caustic soda) is expected to readily comply with the noise level goals and acoustic quality objectives at Yarwun Village and have a "no response" response from shorebirds in the intertidal area.

Glossary of Technical Terms

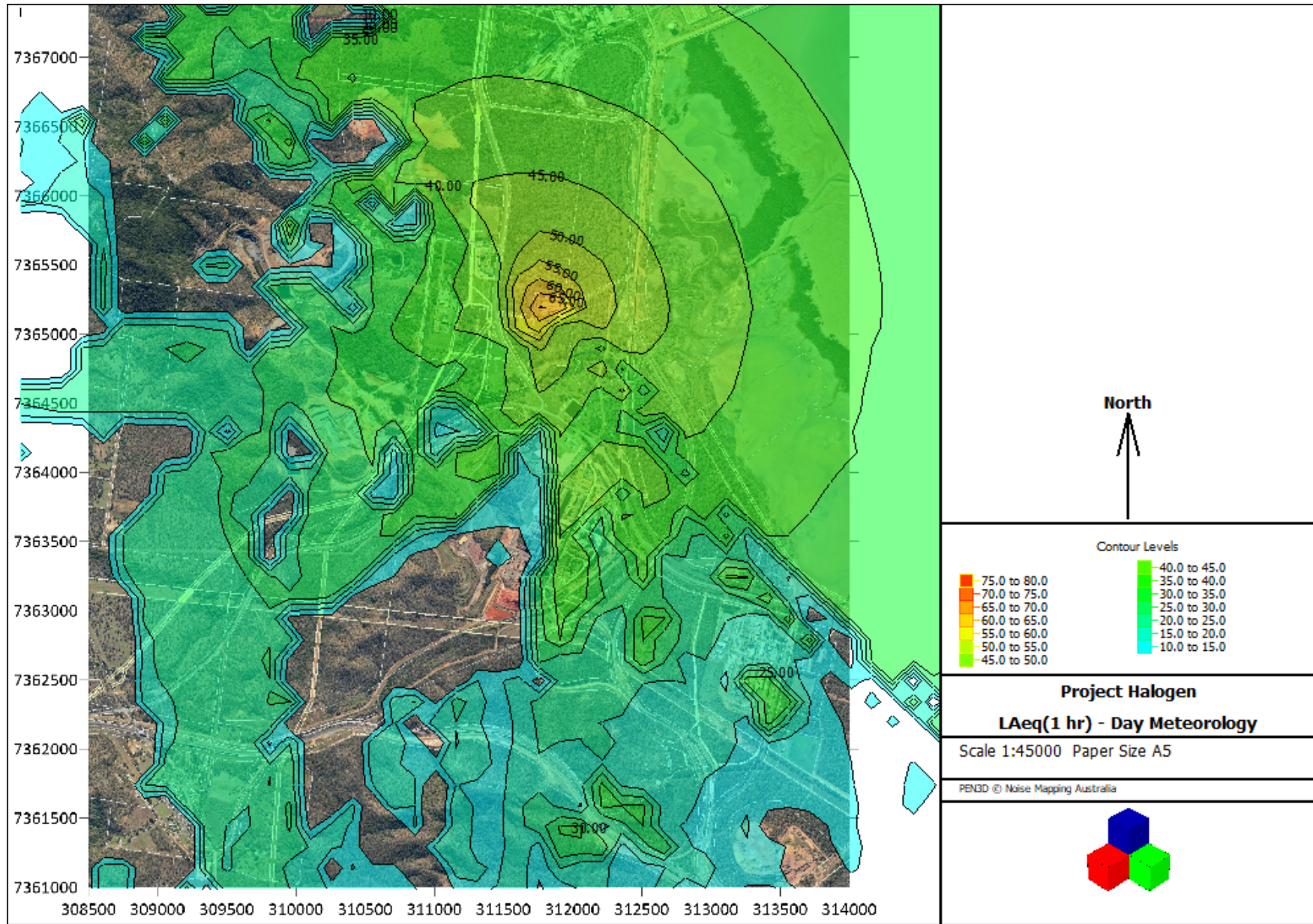
LA01,t	The LA01 is the “A”-weighted statistical noise level exceeded 1% of the time. Commonly accepted time periods (t) include 10 minutes, 15 minutes, 30 minutes, 60 minutes and 24 hours.
LA10,t	The LA10 is the “A”-weighted statistical noise level exceeded 10% of the time. Commonly accepted time periods (t) include 10 minutes, 15 minutes, 30 minutes, 60 minutes and 24 hours. It is sometimes referred to as the average maximum noise level.
LA90 ,t	The LA90 is the “A”-weighted statistical noise level exceeded 90% of the time. Commonly accepted time periods (t) include 10 minutes, 15 minutes, 30 minutes, 60 minutes and 24 hours. It is commonly referred to as the background noise level.
LAeq, t	The LAeq is the “A”-weighted energy average noise level over the time in question. It is the constant noise level containing the same energy as the actual fluctuating noise level. Commonly accepted time periods (t) include 10 minutes, 15 minutes, 30 minutes, 60 minutes and 24 hours.
Adjusted noise level	The LA01 adj,t,, LA10 adj,t,, LAeq adj,t,, is the A-weighted sound pressure level, adjusted for tonal character or impulsiveness when measured using a fast standardised response time.
Day	Refers to the period between 7 am and 6 pm
Evening	Refers to the period between 6 pm and 10 pm
Night	Refers to the period between after 10 pm and before 7 pm
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Assessment background level (ABL)	The single-figure background level representing each assessment period—day, evening and night (i.e. three ABLs are determined for each 24 hour period of the monitoring period). ABL is a measure of background noise level in the absence of noise from the source. Determination of the ABL is by the tenth percentile method, i.e sort the recorded hourly LA90's into ascending order and select the are the lowest ten percentile level.
Rating background level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24 hour period used for the ABL). It is the median value of the ABL's.
Free field	A position where there are no reflecting surfaces, other than the ground, close enough to influence the sound pressure level. Taken as a minimum of 1.2 metres above ground level and 4m from the closest building façade.
Noise floor	The noise floor, inherent or ‘self-noise’ of sound level measuring equipment is the combination of the preamplifier's electrical noise and thermal noise from the microphone.
dB (linear) peak	the maximum reading in decibels (dB) obtained using the “P” time – weighting characteristic as specified in AS 1259.1 – 1990 with all frequency-weighted networks inoperative.
Maximum instantaneous charge (MIC)	the maximum amount of explosive in kg on any one specific delay detonator in any one blast hole.
Peak particle velocity (ppv)	is a measure of ground vibration magnitude and is the maximum instantaneous particle velocity at a point during a given time interval in mms-1. (Peak particle velocity can be taken as the vector sum of the three component particle velocities in mutually perpendicular directions).
octas	Is a rating system describing cloud cover. A clear sky is zero octas while full cloud cover is 8 octas.
residence	includes a building, or part of building, capable of being used as a dwelling.
Sensitive	is an area or place where noise is measured.

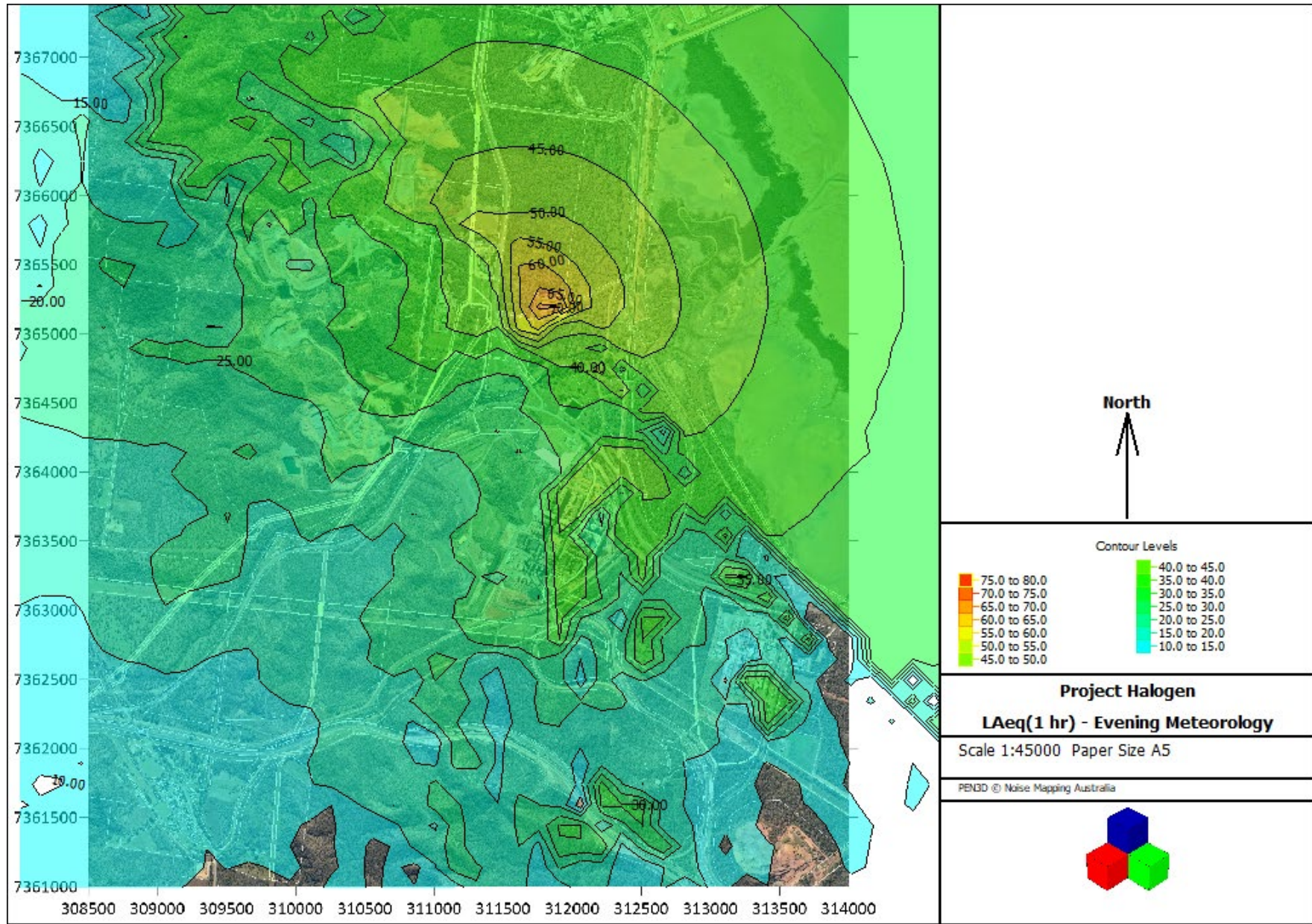
receptor

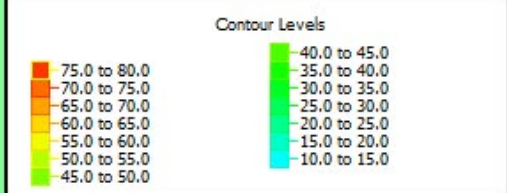
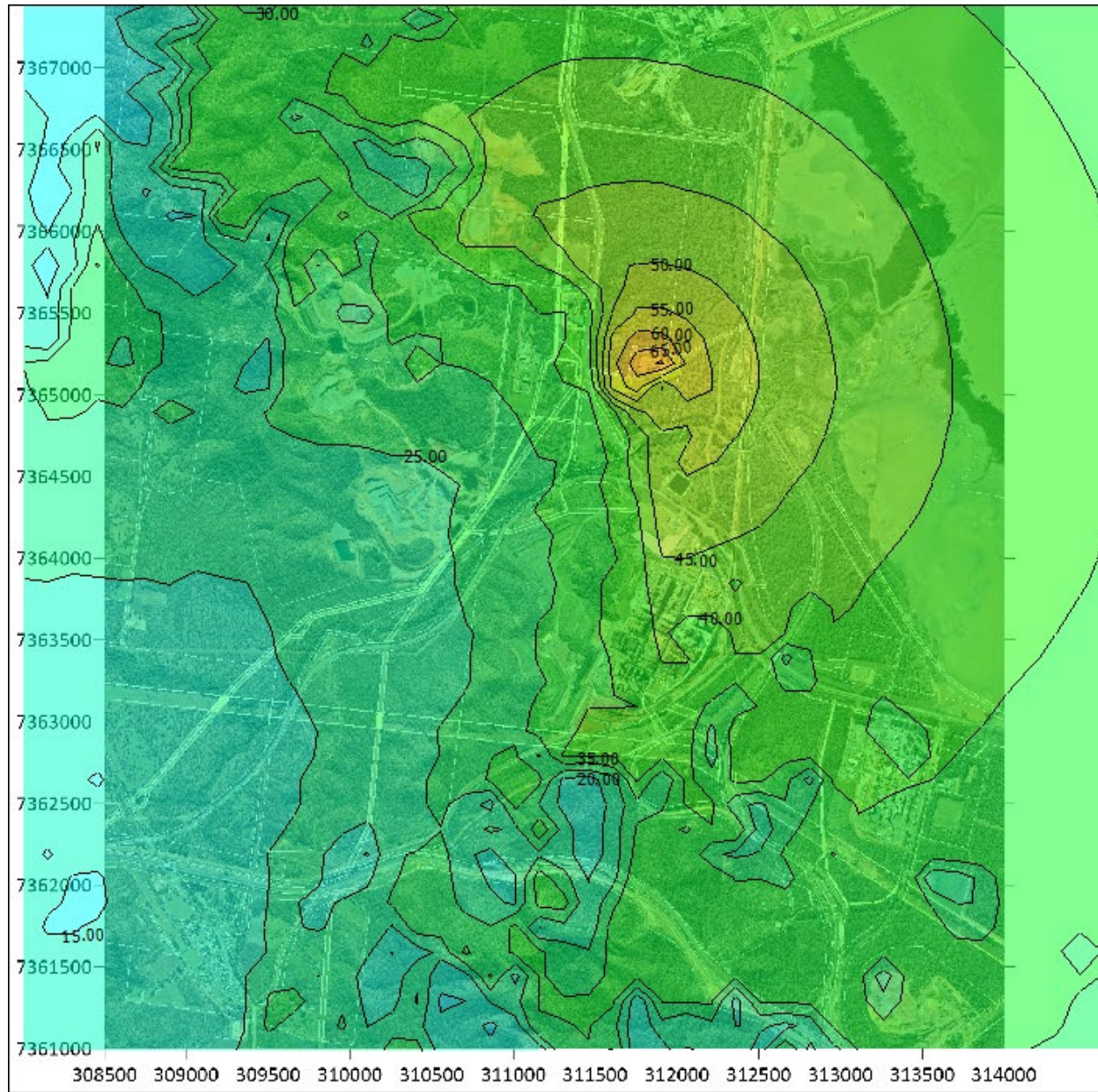
Acoustic quality for a sensitive receptor, is the maximum level of noise that should be experienced in the acoustic environment of the sensitive receptor.

Acoustic environment the part of the environment of an area or place characterised by the total amount of noise that may be experienced there.

Appendix A – Noise Contour Diagrams

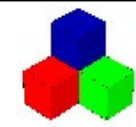


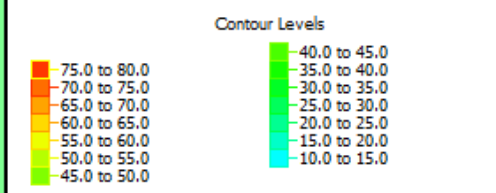
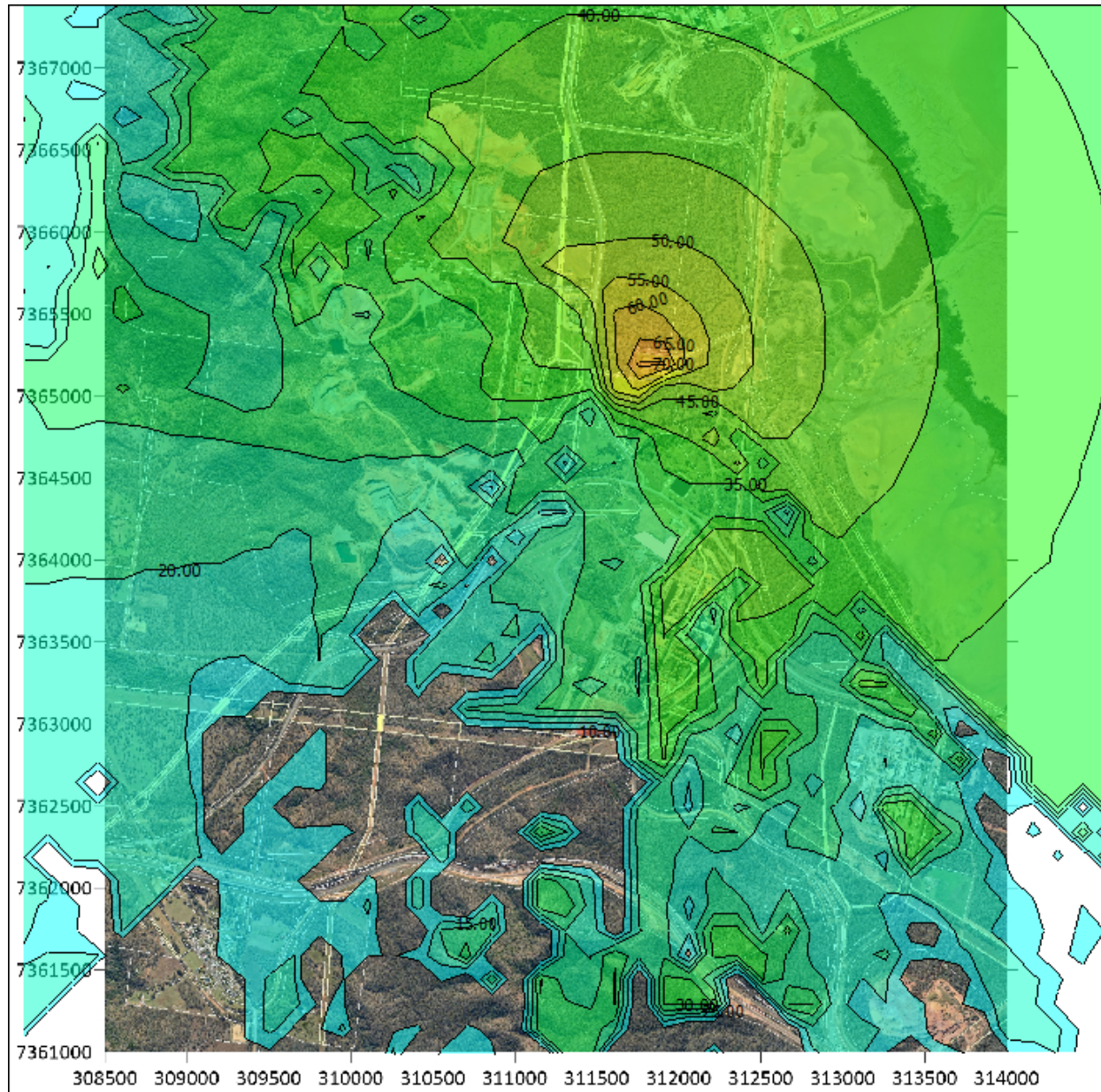




Project Halogen
LAeq(1 hr) - Night (no wind) Meteorology
 Scale 1:45000 Paper Size A5

PENBD © Noise Mapping Australia





Project Halogen
LAeq(1 hr) - Night (SE wind) Meteorology

Scale 1:45000 Paper Size A5

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