URS Australia Pty Ltd

Chris Pigott

Alcan Gove Expansion

Noise Impact Assessment

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ViPAC

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Noise Impact Assessment

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EXECUTIVE SUMMARY

Vipac Engineers & Scientists Ltd (VIPAC) was commissioned by URS Australia Pty Ltd on behalf of Alcan Gove Pty Limited to undertake a noise impact assessment for the Alcan Gove Alumina Refinery Third Stage Expansion.

An operational noise survey was conducted to establish the sound power level of major plant items in the refinery. Manned community noise measurements and noise monitoring were carried out to determine the existing noise impact of the operation.

A noise model was constructed using the SoundPLAN V6.0 environmental noise software to assess the noise impact of the third stage expansion.

Noise predictions indicate that the proposed expansion has very little impact on noise levels in the community. The increase in noise levels at all receivers is less than 1dB(A). The predicted future post–expansion noise levels comply with the proposed 'Background +3/5 dB(A) criteria' at Galupa and the noise levels at other receivers comply with the specified noise levels contained in the Draft Waste Management and Pollution Control (Environmental Noise) Regulation.

The noise impacts of impeller sirens at Inverell Bay, Galupa and Ski Beach Clinic are very minor as the noise levels at these locations elevate by less than 1 dB(A) when sirens wail. The only area where conveyor start-up impeller sirens have a greater impact are the southern part of Nhulunbuy. The noise levels from air-raid sirens are predicted to be 33-34dB(A) at Boxal Street and Enual Road. At these levels, noise from impeller sirens comply with the specified noise levels contained in the draft Regulation and the sleep disturbance criteria.

Road traffic noise during and after construction have been assessed and are found to comply with the $L_{A10(18\ hour)}$ 63dB(A) criterion. The increase is insignificant and no mitigation is required.

Construction noise from intermittent sources such as jackhammer and pile hammers may exceed the construction noise criteria at Galupa. The noise impact can be mitigated by restricting the hours for the use of Jackhammers, pile hammer and concrete saws at construction areas that are close and have direct line of sight to Galupa.

Construction is likely to cause some minor localised vibration due to use of heavy earth moving equipment and pile driving equipment. This vibration will however be negligible at the nearest sensitive receiver due to the large distance from the source.

The operation will not include any significant ground vibration sources and there will therefore be no impact to sensitive receivers from the expansion.

Overall, with the construction noise mitigation measures in place, the noise impact of the third stage expansion will be acceptable.

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1. INTRODUCTION

Vipac Engineers & Scientists Ltd (VIPAC) was commissioned by URS Australia Pty Ltd on behalf of Alcan Gove Pty Limited to undertake a noise impact assessment for the Alcan Gove Alumina Refinery Third Stage Expansion.

The existing Alcan Gove operations consists of a bauxite mine and refinery which converts the bauxite into alumina. The alumina from Gove is exported from the refinery to aluminium smelters around the world.

The Stage 3 expansion will increase total production of alumina from 2 million tonnes per annum (mt/a) to 3.5 mt/a. The proposed expansion is termed the Stage 3 Expansion because it will add a 3rd stage to the current two-stage operation.

The expansion project will include the installation of new plant and equipment which will take place within the existing plant boundaries.

Some occupational noise surveys have been performed at the refinery, however, no environmental noise studies have been taken. The purpose of this study is to address the following issues:

- Conduct a noise survey for the refinery, the conveyor and the surrounding noise sensitive receivers;
- Estimate the noise emissions of the proposed new equipment;
- Develop a noise model to predict noise levels at the nearest sensitive receivers before and after the expansion;
- Assess operational noise impact, by comparison of existing noise levels against predicted future noise levels, as a results of the proposed extension;
- Assess noise impacts during construction;
- Assess noise impacts from the changes to traffic flows for both future operations and construction;
- Assess vibration impacts;
- Develop noise management strategies and practices to reduce noise emissions for both proposed and existing sources; and,
- Prepare a noise environmental management plan.

2. NOISE SENSITIVE RECEPTORS

The operations are located on the Gove Peninsula in the north-east of Arnhem Land in the Northern Territory. The locality map of the operations is shown in Figure 2-1. A town named Nhulunbuy, with a population of 4,000 which was built to support the project and which is mainly populated by company personnel, is located approximately 12 km from the refinery.

There are several noise sensitive communities including (1) Galupa, a small aboriginal community located immediately to the south of the refinery, (2) approximately 30 staff occupied dwellings at Wallaby Beach (2.5 km from the refinery) which will be removed in 2-3 years, (3) a group of people that lives on yachts at Inverell Bay (1.5 km from the refinery) and (4) an aboriginal community at Ski Beach (3.5 km from the refinery). These locations are shown in Figure 2-1.

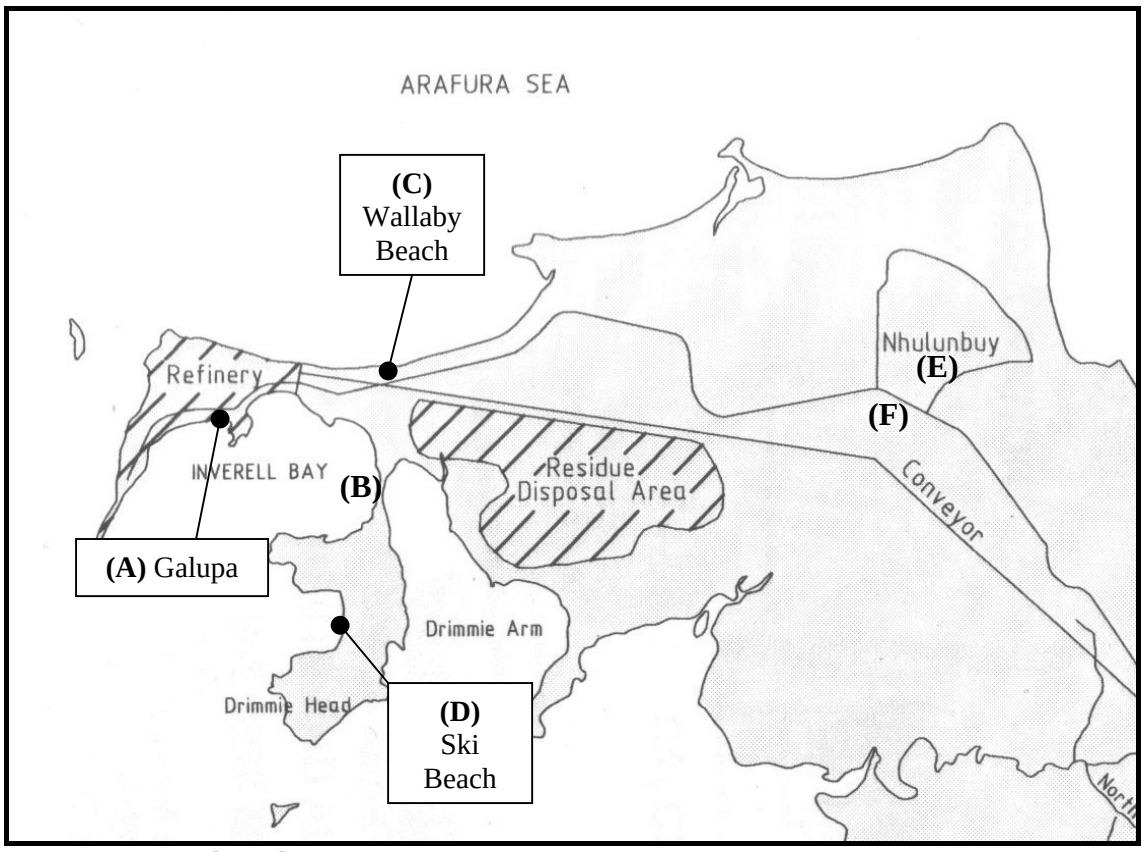


Figure 2-1: Locality Plan

3. GLOSSARY

3.1 ACOUSTIC TERMS

Sound Pressure Level (L_p) – Sound or noise is the sensation produced at the ear by very small fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range (from 20 microPascals to 60 Pascals). A scale that compresses this range to a more manageable size and that is best matched to subjective response is the logarithmic scale, rather than a linear scale.

Sound Pressure Level (L_p) is defined as:

$$L_P = 10\log_{10}\left(\frac{p^2}{p_{ref}^2}\right)dB$$

Where p is the sound pressure fluctuation (above or below atmospheric pressure), and p_{ref} is 20 microPascals (2×10^{-5} μPa), the approximate threshold of hearing. To avoid a scale which is too compressed, a factor of 10 is included, giving rise to the decibel, or dB for short.

A-Weighted Decibel (dB(A)) & Loudness – The overall level of a sound is usually expressed as dB(A), instead of dB. The sound is measured using an A-weighted filter, which is incorporated into the sound level meter. The filter is used to approximate the response of the human ear. It reduces the significance of lower frequencies and very high frequencies, thereby increasing the importance of mid-frequencies (500Hz to 4kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2dB(A) is difficult to detect, whilst a change of 3 to 5dB(A) corresponds to a small but noticeable change. A 10dB(A) change corresponds to a doubling or halving in apparent loudness.

Sound Power Level (L_w) is a measure of the radiated acoustic power of an object. Whereas the sound pressure level of an object varies by the distance and direction from the object, the sound power level is constant for the object. It may be calculated by measuring the sound pressure level over a surface at a defined distance from the object. The L_w is then calculated as the average sound pressure level plus ten times the log of the area of the measurement surface.

Sound Intensity - In areas where there are many noise sources that could affect the sound pressure level, it is best to conduct **sound intensity** measurements. Sound intensity can be considered as the directional sound pressure level. By measuring sound intensity, the direction of the sound can be determined. This ability aids in removing extraneous noise from measurements as the direction of the sound is known. In areas where there is no extraneous noise, (for example a pump in the middle of a field), the sound intensity level and sound pressure level may be equal.

L_{Aeq} is the ***time averaged*** A-weighted sound pressure level for the interval, as defined in AS1055.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

L_{An} is the sound level, which, for a specified time interval, in relation to an investigation of a noise, means the A-weighted sound pressure level that is equalled or exceeded for n% of the interval. Commonly used percentages are 1, 10, 90 & 99%.

L_{Amax} is the **maximum instantaneous** A-weighted Sound Pressure Level obtained using the fast time weighting.

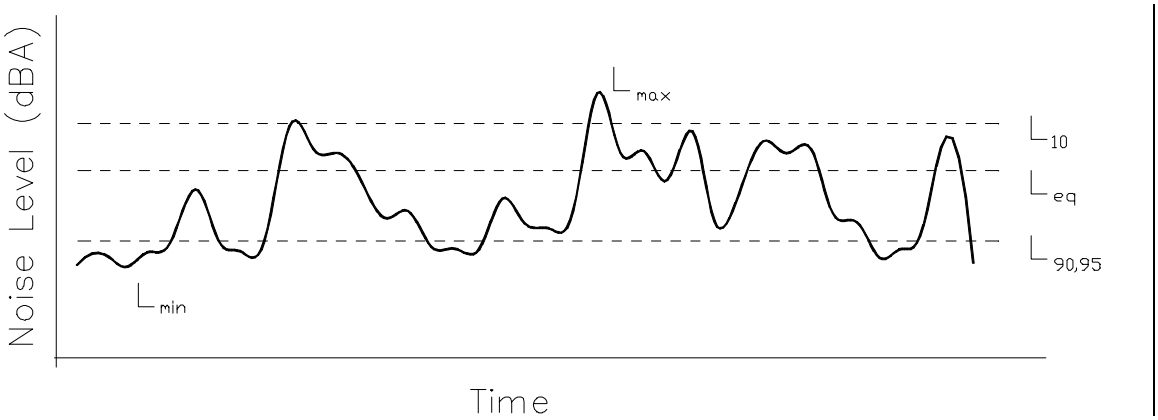
$L_{Amax,T}$ is the ***average maximum*** A-weighted Sound Pressure Level, which, for the specified time interval, means the A-weighted sound pressure level during the interval obtained by using the fast time weighting and arithmetically averaging the maximum sound levels of the noise during the interval. Under certain conditions the 10^{th} percentile noise level, **$L_{A10,T}$**, can represent the average maximum A-weighted sound pressure level.

$L_{Amax,adj,T}$ is the ***adjusted average maximum*** A-weighted sound pressure level, as measured over the time interval T. This is the average maximum A-weighted sound pressure level $L_{Amax,T}$ during the interval, adjusted for any tonal characteristics or impulsiveness as follows (refer also AS1055.1-1997):

- if the tonal characteristic or impulsiveness is just audible
  - add 2-3dB(A) to the measured level;
- if the tonal characteristic or impulsiveness is clearly audible
  - add 5-6dB(A) to the measured level.

L_{Abg} or **L_{A90}** is the ***background*** level, which, for a specified time interval, in relation to an investigation of a noise, means the A-weighted sound pressure level that is equalled or exceeded for 90% of that part of the interval in which the investigated noise is absent.

Hertz (Hz) are units of frequency, equal to one cycle per second.



Octave frequency bands allow a representation of the spectrum associated with a particular noise. They are an octave wide, meaning that the highest frequency in the band is just twice the lowest frequency, with all intermediate frequencies included and all other frequencies excluded. Each octave band is described by its centre frequency.

Third (1/3) octave frequency bands provide a little more information. Third octave bands are bands of frequency approximately one third of the width of an octave band.

Narrow band or **Fast Fourier Transform (FFT)** spectrum carries detailed frequency information. The amount of detail is related to the size of the spectrum and the number of lines in the spectrum.

Harmonics are multiples (2x, 3x, etc) of a fundamental frequency component.

3.2 METEOROLOGY

Pasquill stability classes. There are seven Pasquill stability classes (A to G) used to describe the atmospheric stability (i.e. vertical temperature gradient). Where category A represents a strong lapse condition (large temperature decrease with height), and category G, on the other hand, represents a temperature inversion as may be observed on a clear night.

Neutral meteorological conditions are considered to be non enhancing in terms of noise propagation. Pasquill stability classes C and D with no wind would be considered neutral.

Favourable meteorological conditions are considered to reduce the impact of noise emissions from plant to noise sensitive receiver. These conditions may include high wind speeds, whereby the background noise levels are raised due to wind generated noises or unstable atmospheric conditions (Pasquill classes A or B) with wind from the receiver to the plant.

Adverse meteorological conditions are considered to be enhancing in terms of noise propagation. Stable atmospheric conditions (Pasquill classes F or G) with light winds from plant to noise sensitive receivers would be considered to be adverse meteorological conditions.

4. NOISE AND VIBRATION GUIDELINES

4.1 Industrial noise

There is no environmental noise legislation and criteria for the mining and refinery industries in Northern Territory.

The Northern Territory government's Draft Waste Management and Pollution Control (Environmental Noise) Regulation ('the Regulation') has specific maximum noise pollution levels for various aspects of noise including community activities, construction sites, residential premises, agricultural equipment on rural premises, special sporting, cultural and entertainment events, and vehicles, train etc.

The specific maximum noise pollution levels for residential areas are tabulated in Table 4-1.

Table 4-1: Maximum Noise Pollution Levels

Noise receiving area	**Time of day**	**L_{A10} dB(A)**	**L_{A1} dB(A)**	**L_{Amax} dB(A)**
Area 4: An area of noise –sensitive premises that is within 15m of a building used for noise-sensitive purposes on the premises, where the building is more than 100m from – (a) a road carrying more than 10,000 vehicles per day; or (b) a significant business	7am to 7pm Mon-Sat	45	55	65
	9am to 7 pm Sunday & Public holiday	40	50	65
	7pm to 10pm all days	40	50	55
	10pm on any day to 7am Mon – Sat and 9am Sunday & public holiday	35	45	55
Area 5: An area of noise –sensitive premises that is within 15m of a building used for noise-sensitive purposes on the premises, where the building is within 100m from – (a) a road carrying more than 10,000 vehicles per day; or (b) a significant business	7am to 7pm Mon-Sat	50	60	70
	9am to 7 pm Sunday & Public holiday	45	55	70
	7pm to 10pm all days	45	55	60
	10pm on any day to 7am Mon – Sat and 9am Sunday & public holiday	40	50	60

Note: The above noise limits do not apply to the mining and refinery industries.

A 'Background +3/+5 dB(A) criteria' is regularly used by Environmental Protection Agencies (EPA's) and local councils in other states when specifying noise criteria or assessing noise complaints for industries. These are widely accepted as being appropriate noise limits for non-time-varying noises, such as mechanical plant, and for minimising the risk of noise complaint. These limits are shown in Table 4-2.

Table 4-2: Environmental Noise Limits for an Environmentally Relevant Activity

Noise Limits at a Noise Sensitive Place Measured as the Adjusted Maximum Sound Pressure Level $L_{Amax,adj}$	Period
Background noise level plus 5 dB(A)	7am - 6pm
Background noise level plus 5 dB(A)	6pm - 10pm
Background noise level plus 3 dB(A)	10pm - 7am
Noise Limits at a Commercial Place Measured as the Adjusted Maximum Sound Pressure Level $L_{Amax,adj}$	Period
Background noise level plus 10 dB(A)	7am - 6pm
Background noise level plus 10 dB(A)	6pm - 10pm
Background noise level plus 8 dB(A)	10pm - 7am

For this project, we propose to assess the noise impacts with the specific maximum noise pollution levels in the Draft Waste Management and Pollution Control (Environmental Noise) Regulation, and the widely used 'Background +3/+5 criteria'.

Since Galupa is located immediately adjacent to the refinery and the existing noise level at this location is already relatively high, it would be more appropriate to compare the noise impact before and after the expansion rather than using absolute value. Thus, the noise impact at Galupa is assessed with the 'Background +3/+5 criteria'. At other noise sensitive receptors, the noise impact is assessed with the specific maximum noise pollution levels.

4.2 Construction Noise

The Regulation specifies that construction work must comply with the noise limits contained in Table 4-1 and satisfy the procedures and conditions in Part 4 of the Regulation before carrying out construction works.

In Part 4 - Specific Maximum Noise Pollution Level, the Regulation states*:*

"13. Noise from construction sites between 7 am and 7 pm weekdays or Saturday

Noise emitted from a construction site as a result of construction work carried out between 7 am and 7 pm on a day that is not a Sunday or public holiday is to be taken to comply with regulation 3 if the occupier of the construction site establishes that-

a. the construction work was carried out in accordance with the control of environmental noise practices set out in section 6 of AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites.
b. The equipment used on the construction site was the quietest reasonably available; and
c. where the occupier was required to prepare a construction noise management plan under regulation 15 in respect of the construction site-

- *The plan was submitted under regulation 15 by the date specified in the notice;*
- *The plan was approved under regulation 15; and the construction work was carried out in accordance with the construction noise management plan approved under regulation 15.*

14. Noise from construction sites at other times or day

Noise emitted from a construction site as a result of construction work carried out-

a. between 7 pm and 7 am on a day; or
b. at any other time on a Sunday or public holiday,

is to be taken to comply with regulation 3 if the occupier of the construction site shows that -

a. the construction work was carried out in accordance with the control of environmental noise practices set out in section 6 of AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites.
b. The equipment used on the construction site was the quietest reasonably available;
c. The construction work was carried out in accordance with a construction noise management plan in respect of the construction site-

i. submitted to the Chief Executive Officer not later than 7 days before the construction work commenced;
ii. approved by the Chief Executive Officer under regulation 15(5);

d. at least 24 hours before the construction work commenced, the occupier of the construction site gave written notice of the proposed construction work to the occupiers of all premises in relation to which it is likely regulation 3 would , apart from this regulation, not be complied with; and
e. it was reasonably necessary for the construction work to be carried out at that time.'

Note: Table 4-1 shows the Regulation 3 noise limits.

4.3 Road Traffic Noise

The Regulation does not contain planning levels for public roads. For this study, we recommend to use the planning levels for road traffic noise in Queensland for assessing the additional operational vehicular traffic impact.

The Queensland Environmental Protection Policy (Noise) refers to planning levels for road traffic noise. These planning levels, in Schedule 1 of the EPP (Noise), are:

Public Roads
2. *The planning levels for a public road are the following noise levels, assessed 1 m in front of the most exposed part of an affected noise sensitive place –*
(a) the following levels assessed as the L10 (18 hour) level –
(i) for a state-controlled road - 68 dB(A)
(ii) for another public road – 63 dB(A)
(b) 60 dB(A), assessed as the highest 1 hour equivalent continuous A-weighted sound pressure level between 10:00 p.m. and 6:00 a.m.;
(c) 80 dB(A), assessed as a single event maximum sound pressure level.

These criteria are planning levels for new roads but can be used for assessment of existing roads with increased traffic flows.

4.4 Ground Vibration

There are no ground vibration criteria in Northern Territory. For this study, we recommend to use the ground vibration criteria used in Queensland to assess the vibration impact.

The Queensland Environmental Protection Regulation (EPR) includes criteria for noise and ground vibration as a result of blasting. There is no other specific Queensland legislation pertaining to ground vibrations. For general construction and earthworks activities, alternative specific criteria are used for ground vibration levels at receiver locations in terms of building damage and for human comfort. The EPR states in *Part 2A – Environmental Nuisance, Division 1 – Preliminary, Subdivision 4 – Meaning of unlawful environmental nuisance, Section 6I*:

Blasting noise exclusion

6I. *Noise from blasting is not unlawful environmental nuisance for an affected building if –*

(a) the air-blast overpressure is not more than 115 dB (Lin) Peak for 4 out of any 5 consecutive blasts; and

(b) The ground vibration is-

(i) for vibrations of more than 35 Hz - no more than 25 millimetres per second ground vibration, peak particle velocity; or

(ii) for vibrations of not more than 35 Hz - no more than 10 millimetres per second ground vibration, peak particle velocity.

4.5 World Health Organisation – Sleep Disturbance

The World Health Organisation (WHO) "*Guidelines for Community Noise*" contains criteria for the assessment of sleep disturbance. It states that health effects on sleep are negligible at levels below 30 dB(A) L_{Aeq} for a sources of a continuous nature. It is suggested that for noise with a large low frequency content a level lower than 30 dB(A) L_{Aeq} (inside bedrooms) is recommended, however no exact value is stipulated. For short duration, non-continuous noise levels, maximum noise levels should not exceed 45 dB(A) L_{Amax} (inside bedrooms) when background noise levels are low.

The "*Guidelines*" assume a noise reduction of a dwelling to be in the order of 15 dB(A) to determine sleep disturbance criteria for outside bedrooms. This is likely to be excessive for Northern Territory conditions as bedroom windows are typically open due to the warm climate. Noise reductions of at least 5 dB(A) and not more than 10 dB(A) are expected.

In summary, recommended WHO noise levels outside bedrooms to prevent sleep disturbance are:

- 35 dB(A) L_{Aeq} for noise sources that are continuous in nature; and
- 50 dB(A) L_{Amax} for short duration, non-continuous noise levels.

5. EXISTING NOISE ENVIROMENT

5.1 Operation noise survey

An operation noise survey was conducted between 3rd and 6th June 2003 to establish the sound power level of major plant equipment which are subsequently used in noise modelling.

There are three main noise emission areas from the operation: refinery, conveyor and mine.

Noise sources at the refinery include pumps, motors, process equipment, fans, compressors, turbines, vehicles and conveyors, etc.

There are 17 main noise emission areas in the existing refinery which are listed as follows:

1. Calcination (Stationery calciner)
2. Steam Power Station (Boiler)
3. Hydrate
4. Precipitation
5. Pump House
6. Deep Washer (Ferrosilt)
7. Grinder (Mills)
8. Evaporator
9. Calciner (Rotary Kiln)
10. Lime Plant
11. Digestion
12. Diesel Power Station
13. Security Filtration
14. Tank Farms
15. Silo
16. Conveyor
17. Cooling tower

Figure 5-1 shows the locations of the 17 areas. The major noise sources in each area are tabulated in Table 5-1.

Amongst these 17 areas, the most dominant noise emission areas are #3 Hydrate, #1 & #9 calcination, #17 cooling tower and #12 steam power station etc. The vacuum pumps from (3) Hydrate emit low frequency noise at very high sound pressure level (90dB(A) overall & 83dB(A) at 250Hz at 10m outside vacuum pump room).

The conveyor runs between the refinery and the mine. There are 2 types of sirens for conveyors start-up: (i) five impeller (air-raid) sirens mounted along the conveyor and (ii) building mounted sirens on transfer stations with lower noise level. The impeller sirens have a very high sound power level (SWL of 138dB(A)) and are audible over a long distance.

While the existing mining rate will increase, no significant change in the mining area is required. Thus, noise from mining activities are not considered in this study.

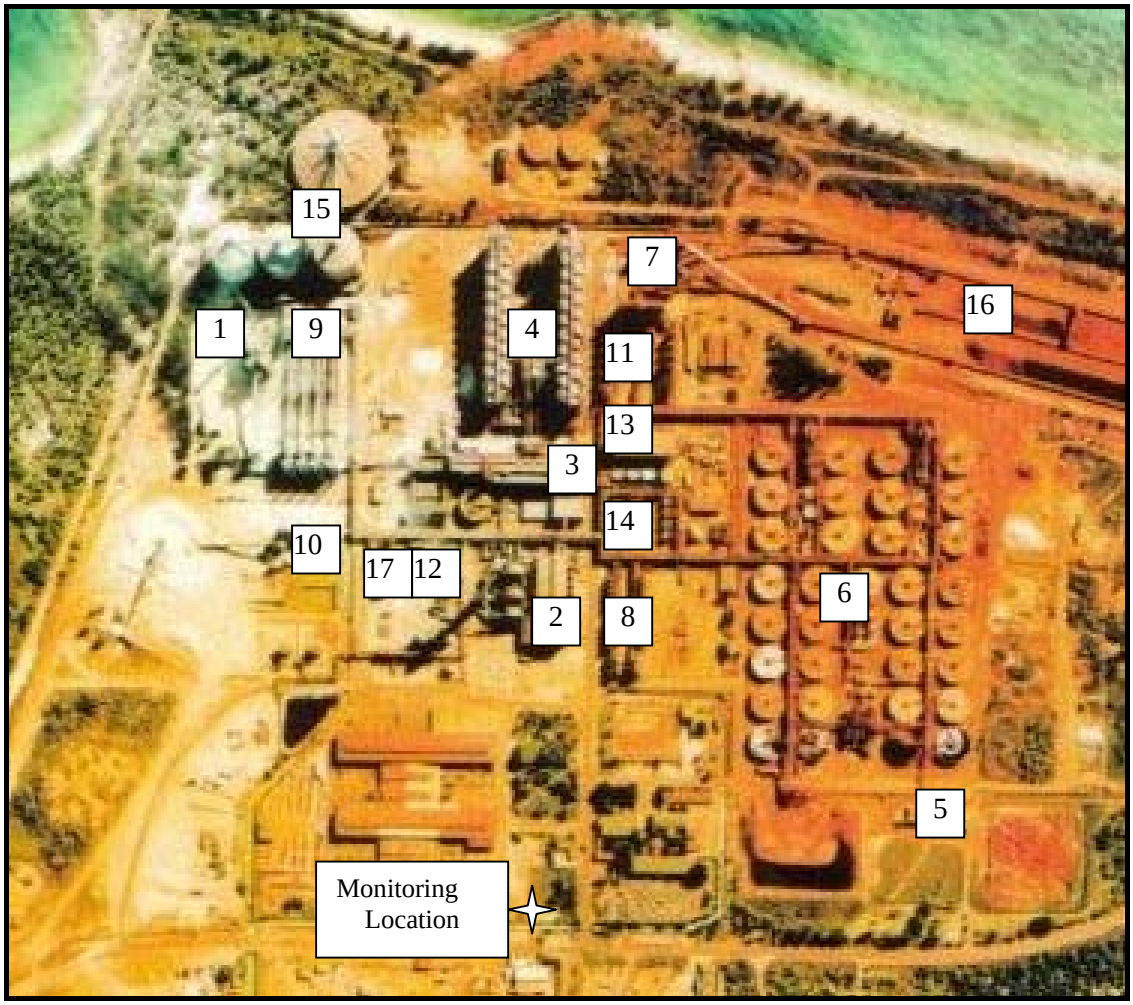


Figure 5-1: Refinery Noise Emission Areas

Table 5-1: Major Noise Sources In Each Area Within the Refinery

Area	Major Noise Sources
1. Calcination (Stationery calciner)	Blower rooms, pressurising fans for blower rooms
2. Steam Power Station (Boiler)	Inside building: boiler Feed Pumps, process Air Compressors, turbines Outside Building: FD Fans, exhaust stack
3. Hydrate	Pumps, stack, vacuum pump room
4. Precipitation	Transfer pumps and sump pumps
5. Pump House	Pumps including sump pumps and transfer pumps etc.
6. Deep Washer (Ferrosilt)	Sump pumps, warmer pumps, hydro feed pumps, slurry pumps, agitators, fans, thickener pumps, turbid liquor pumps, dilution pumps, overflow pumps, underflow pumps, heat exchangers, sand disposal pump, deep wash underflow pump, thickener overflow pump 2x

Table 5-1: (Continued)

Area	Major Noise Sources
7. Grinder (Mills)	Motors, mills, sump pumps, injection pumps
8. Evaporator	Pure condensate return pumps, strong liquor discharge pumps, recycle pumps, heat exchangers
9. Calciner (Rotary Kiln)	Rotary kilns, air blowers, blower room
10. Lime Plant	Blower room, pumps
11. Digestion	Discharge pumps
12. Diesel Power Station	Diesel generators inside building
13. Security Filtration	Cleaning Liquor pumps, sump pumps, monger pumps TLR pumps, red mud pumps, hydraulic pumps, Kelly filter, hydraulic pumps, PGL pumps
14. Tank Farms	SRL Strong feed pumps, fresh caustic pumps, process condensate pumps, Spent liquor pumps
15. Silo	Compressor room, blower room
16. Conveyor	Conveyors, motors, sirens
17. Cooling tower	Fans, water falling

5.2 Background noise monitoring

Background noise monitoring was initially planned to be carried out at Galupa and Ski Beach. However, access to Galupa was not possible at the time of the survey and monitoring was carried out at the southern end of the refinery (approximately 200m northwest of Galupa) instead.

Noise monitoring was conducted at the (1) southern end of the refinery near the gate house (See Figure 5-1) and (2) Ski beach clinic, between 4th and 6th June 2003.

Noise levels have been measured in accordance with the Draft Waste Management and Pollution Control (Environmental Noise) Regulation. The monitoring results, expressed as L_{A10}, L_{Aeq} and L_{A90} levels, are shown in Figures 5-2 and 5-3. The background noise levels measured at these locations are presented in Table 5-2. These levels are the 75th percentile of the measured L_{A90} levels.

Table 5-2: Summary of the background noise results

Location	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Southern end of refinery	51.9	52.1	53.5
Ski beach clinic	31.1	29.8	27.7

Meteorological data shows that the weather was fine with moderate south-easterly and southerly wind during the monitoring period.

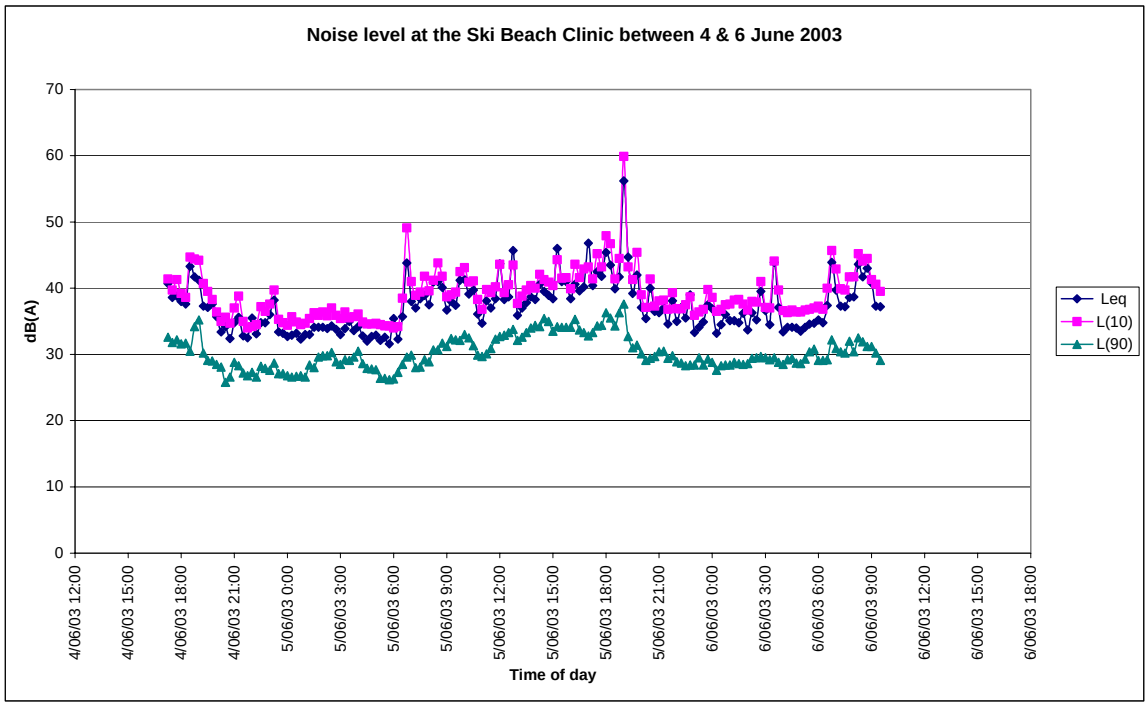


Figure 5-2: Noise levels at the Ski Beach Clinic between 4 & 6 June 2003

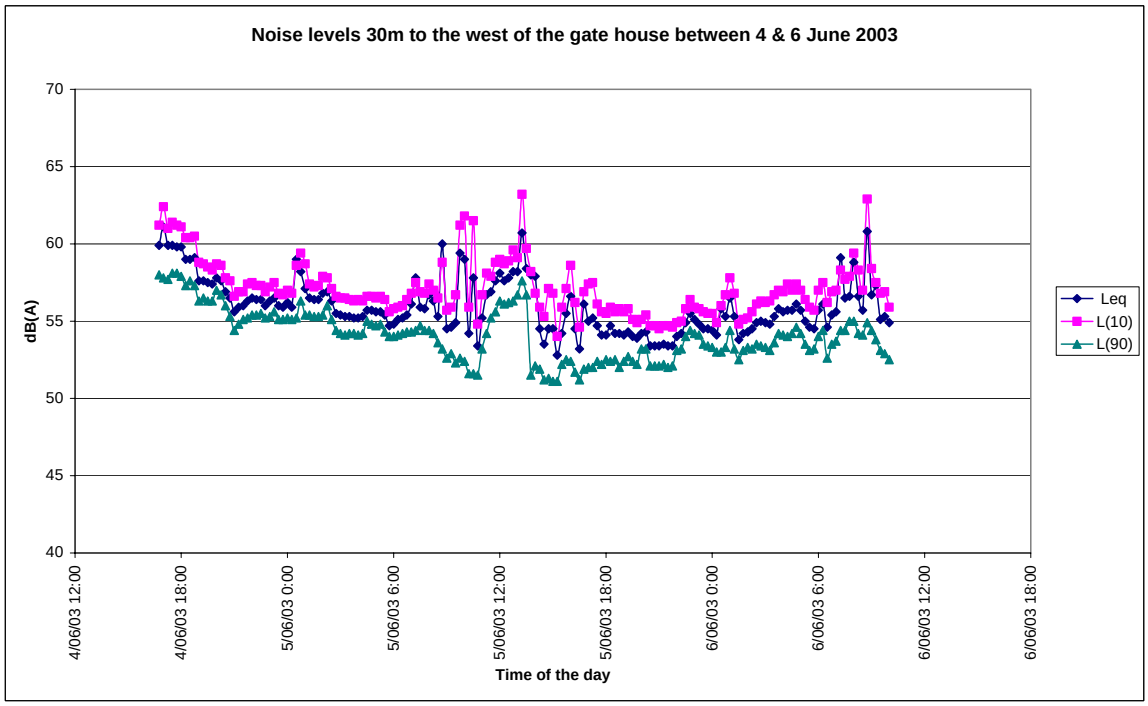


Figure 5-3: Noise levels at 30m to the west of the gate house between 4 & 6 June 2003

5.3 Community noise measurements (Manned)

Manned community noise measurements were carried out at around midnight on 5th & 6th June 2003 to determine the existing noise impact of the operations. As the refinery and conveyor are 24 hours operation, measurements were carried out at around midnight when wind and insect noise are expected to be low.

Noise levels have been measured in accordance with the Draft Waste Management and Pollution Control (Environmental Noise) Regulation.

Measurements were taken at Inverell Bay, Wallaby Beach, Galupa, Ski Beach and Nhulunbuy. During the measurements, weather was fine with moderate south-easterly and southerly wind.

At Galupa, noise from the Refinery was audible and the noise levels generally ranged between 52dB(A) and 60dB(A). At Wallaby Beach, the major noise sources were insects, conveyor, traffic and surf noise. At Inverell Bay, Enalu Road and Boxal Street at Nhulunbuy, conveyor noise was faintly audible. At Ski Beach, some distant machinery noise was faintly audible occasionally but we were not sure whether that was refinery or conveyor noise. A summary of the noise measurement results is tabulated in Table 5-3.

Table 5-3: Summary of manned noise measurement results

Date	Time	Location (Refer to Figure 2-1)	L_{A1} dB(A)	L_{A10} dB(A)	L_{A90} dB(A)	L_{Aeq} dB(A)	Comments
5-Jun-03	23:34	Inverell Bay **(B)**	53.5	37.7	25.5	32.8	Surf, conveyor noise faintly audible
5-Jun-03	23:55	Wallaby Beach **(C)**	53.5	51.4	49.8	50.7	Cicada, insect, conveyor, surf & traffic
6-Jun-03	0:13	Adjacent to Galupa on Melville Bay Road **(A)**	65.3	59.1	52.7	53.6	Insect, refinery, pumps from wharf
6-Jun-03	0:21	Ski Beach Clinic **(D)**	47.2	43.1	38.1	41.4	Dominated by insect noise, machinery noise faintly audible occasionally-unsure whether it was conveyor or refinery noise
7-Jun-03	0:04	Corner of Matthew Flinders Way & Arnrem Road near Toyota dealer **(E)**	44.7	43.5	36.8	37.7	Insect, traffic
7-Jun-03	0:11	End of the bitumen section of Enalu Road at the gate **(F)**	38.3	34	31.4	32.7	Whining sound from conveyor just audible, wind rustling leaves
7-Jun-03	0:15	Same as above **(F)**	38.1	32.3	29.8	31.4	Whining sound from conveyor just audible
7-Jun-03	0:20	Boxal Street **(F)**	37.8	32.6	30.3	32.3	Whining sound from conveyor just audible
7-Jun-03	0:40	Same as above **(F)**	38.8	36.2	33.5	35.9	Whining sound from conveyor just audible, wind rustling leaves

6. OPERATIONAL IMPACTS

Noise levels from the refinery and conveyor are known to be relatively steady and continuous for 24 hour operation and consequently this assessment has not differentiated the predicted noise levels between day, evening and night periods. Instead, focus has been on the prediction of noise levels under different meteorological conditions.

6.1 Noise Model

A noise model was constructed using the SoundPLAN V6.0 environmental noise software to assess the noise impact of the third stage expansion. SoundPLAN was developed by Braunstein & Berndt International, a leading firm of transportation and environmental engineers in Germany. The software is used worldwide by over 600 companies and is one of the leading software products available for road, rail and industry noise prediction.

The environmental noise model was generated using SoundPLAN's industry module. The industry module is comprehensive and allows:

- modelling of sound power sources in third octaves;
- modelling of noise sources as point, line or area sources;
- 2D and 3D directivity of sources;
- 3D topography;
- noise source ranking;
- use of various industry noise models (Nordic, Concawe, etc); and
- screening and meteorological effects.

The CONCAWE noise propagation algorithms were used in this study. The CONCAWE method is described in a research paper (Manning, 1981) and is specially designed for the requirements of large industrial facilities. This method is the only one dealing explicitly with the influence of wind and the stability of the atmosphere using Pasquill stability categories. There are seven Pasquill stability categories (A to G) used to describe the atmospheric stability (i.e. vertical temperature gradient). Category A represents a strong lapse condition (large temperature decrease with height), and category G, represents a temperature inversion as may be observed on a clear night. Pasquill stability categories are a component of the CONCAWE algorithms.

6.2 New Noise Sources Design Basis

Increased refinery production will be achieved by installing new process equipment which will integrate into the existing refinery process. These new process equipment include:

(A) Solid liquid calciner (New Plant)
(B) Add boiler to power station
(C) Add evaporators
(D) Add more digesters (Cylinders)
(E) Add more precipitators
(F) Add more classifiers (hydrate)
(G) Add stationary calciner

The locations of the new equipment are shown in Figure 6-1. The design levels of the new equipment are L_{Amax} 85dB(A) at 1m. The equipment inventory and their associated sound power level and spectra are not known at this stage. Therefore, the sound power levels of the new process equipment are calculated based on noise measurement of existing similar equipment. Some levels are estimated, due to either lack of available sound power

information, or for plant/equipment that is not yet constructed. In addition, the following assumptions have been made:

- New sources are steady and do not have tonal, impulsive characteristics that could be detected in the community;
- Area A (Solid Liquid Calciner) –noise spectra and the sound power level of the new equipment will be similar to the existing Stationary Calciner. The blower room and the pressurising fan will be located at the northern end of the area facing away from Galupa;
- Area B (Power Station) –noise spectra similar to the existing power station and the sound power level of the new equipment will be **5 dB(A) lower** than the existing power station due to new technology and fewer new equipment than existing power station;
- Area C (Evaporators) –noise spectra similar to the existing evaporators and the sound power level of the new equipment will be **3 dB(A) lower** (half of the sound energy) than the existing equipment due to new technology and fewer new equipment than the existing evaporation area. A new cooling tower for the evaporators will be located immediately to the south of the Area A. The noise spectra and the sound power level of the new cooling tower will be similar to the existing cooling tower to the west of the power station;
- Area D (Digesters) – The new equipment will be more than double of the existing equipment in this area. We assume the sound power level of the new equipment will be the similar to the existing digesters area due to new technology;
- Area E (Precipitators) – noise spectra similar to the existing precipitators and the sound power level of the new equipment will be **3 dB(A) lower** (half of the sound energy) than the existing equipment due to new technology and fewer new equipment than the existing precipitation area;
- Area F (Classifiers) – noise spectra similar to the existing hydrate area and the sound power level of the new equipment will be **10 dB(A) lower** (1/10 of the sound energy) than the existing equipment due to quieter vacuum pumps, fewer new equipment than the existing hydrate area and use of enclosures; and,
- Area G (Stationary Calciner) – noise spectra similar to the existing stationary calciner and the sound power level of the new equipment will be **3 dB(A) lower** (half of the sound energy) than the existing equipment due to new technology.

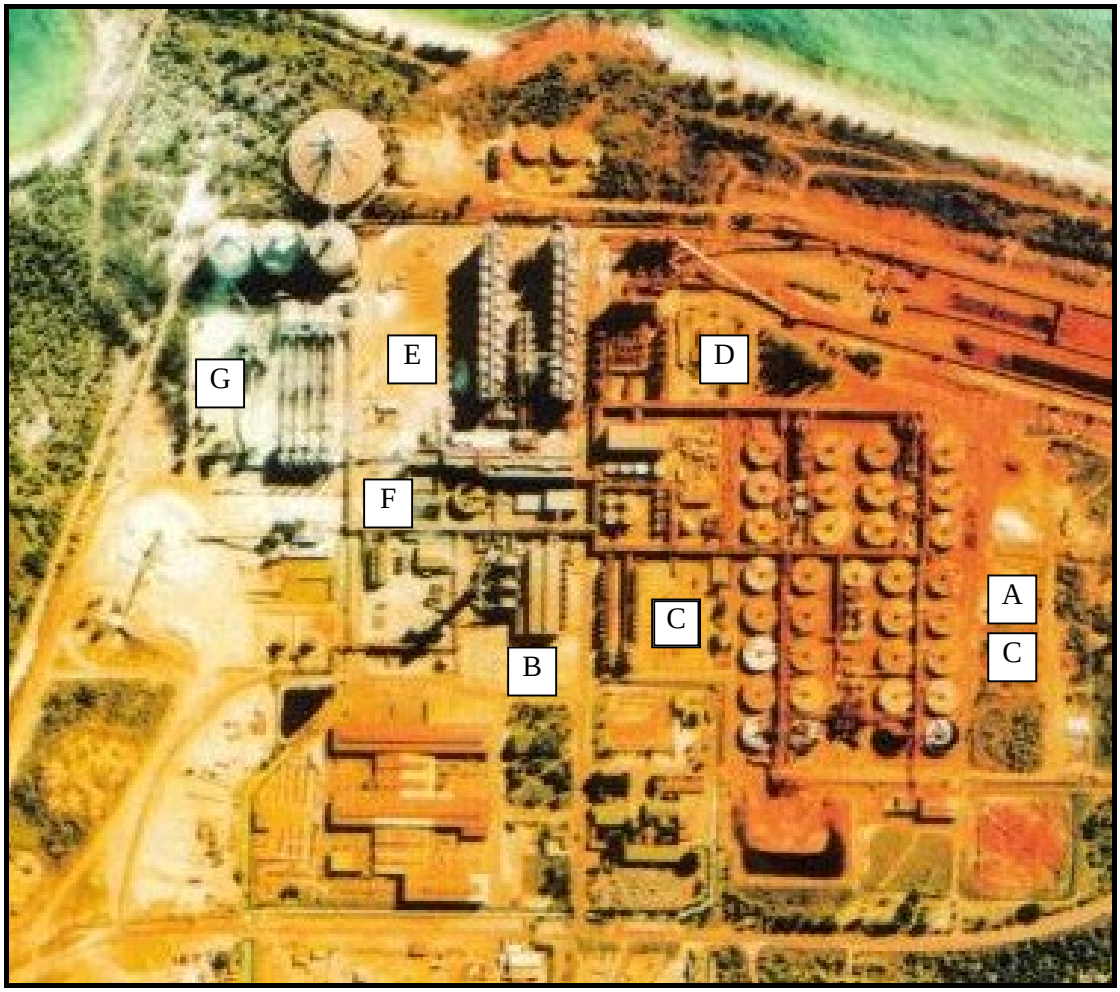


Figure 6-1: Locations of new equipment

6.3 Meteorological Considerations

The climate on the Gove Peninsula is tropical monsoonal, with a marked seasonal variation in winds and rainfall.

The year is divided roughly into a wet season between December and April and a dry season between May and November, but transitional conditions tend to blur the boundary between the seasons. The wet season is characterised by high humidity and frequent rainfall, with wind frequently from the north west. Tropical cyclones can occur in the Gove area during this season, and a high percentage of rain falls in intense thunderstorms and showers. During the dry season conditions are typically less humid with south-easterly winds.

Mean daily maximum temperatures vary from 33.1^{0}C in November to 27.7^{0}C in July. The mean daily minimum temperature varies from 24.6^{0}C in January to 19.3^{0}C in August.

The noise levels at noise sensitive receivers can increase by up to 12dB(A) under adverse meteorological conditions (i.e. varying wind speed, direction and Pasquill Stability class) and decrease by up to 7dB(A) under favourable conditions.

The noise levels at night under both dry and wet conditions are predicted and the parameters used are shown below.

Dry Conditions

Temperature	20C
Humidity	70%
Atmospheric conditions	Stable, Pasquill category F
Wind Speed	2 m/s
Wind Direction	from SE (noise away from residential areas)

Wet Conditions

Temperature	25C
Humidity	90%
Atmospheric conditions	Stable, Pasquill category F
Wind Speed	2 m/s
Wind Direction	from NW (noise towards residential areas)

6.4 Accuracy of the Model

The existing refinery operations have been modelled and compared to measurements adjacent to Galupa and the monitoring result at the southern end of the refinery. The prediction results are continuous noise levels, which are in terms of L_{Aeq}. At the monitoring location inside the refinery and measurement locations adjacent to Galupa, there are many local and intermittent noise sources such as sirens and alarms etc. which increase the L_{Aeq} level. At these locations, the continuous noise levels would be better represented by the L_{A90} levels. Thus, the prediction results are compared with the background L_{A90} monitoring and measurement levels The prediction and measurement results are tabulated in Table 6-1.

Table 6-1: Summary of prediction and measurement results

Location	Prediction results L_{Aeq} dB(A)	Measurement results L_{A90} dB(A)
Monitoring Location	54.1	53.5
Adjacent to Galupa on Melville Bay Road	52.3	52.7

On average the modelling and measurements are found to be ± 1 dB(A) and this level of accuracy is considered acceptable. It should be noted that the accuracy at other locations is expected to be within ± 3-5 dB(A)

7. NOISE MODELLING RESULTS

Noise levels under different conditions are predicted at the noise sensitive locations. 6 scenarios have been modelled. A description of these scenarios are listed as follows

1. Pre-expansion during wet season
2. Post-expansion during wet season
3. Pre-expansion during dry season
4. Post-expansion during dry season
5. 5 impeller sirens along conveyor during dry season (Post-expansion)
6. 5 impeller sirens along conveyor during wet season (Post-expansion)

The modelling results are tabulated in Tables 7-1 and 7-2. Colour noise contour maps presented in Figures 7-1 and 7-2 show the noise levels in the study area during dry and wet seasons post-expansion.

Table 7-1: Predicted Noise levels (L_{Aeq}) from the refinery during wet and dry seasons before and after expansion

Location	Wet Season		Difference (post-pre) dB(A)	Dry Season		Difference (post-pre) dB(A)
	Pre dB(A)	Post dB(A)		Pre dB(A)	Post dB(A)	
Boxal Street	27.6	27.6	0	27.5	27.5	0
Enalu Road	28.9	29.0	0.1	28.7	28.7	0
Banyan Road	9.8	10.5	0.7	9.7	10.4	0.7
Inverell Bay	38.3	38.6	0.3	33.3	33.5	0.2
Galupa	48.2	49.0	0.8	47.7	48.4	0.7
Ski Beach Clinic	27.6	28.4	0.8	23.4	24.0	0.6
Wallaby Beach	37.6	38.1	0.5	37.8	38.0	0.2

Table 7-2: Predicted Noise levels with impeller sirens during wet and dry seasons

Location	Dry season		Difference dB(A)	Wet season		Difference dB(A)
	Without Sirens dB(A)	With Sirens dB(A)		Without Sirens dB(A)	With Sirens dB(A)	
Boxal Street	27.5	33.1	5.6	27.6	33.3	5.7
Enalu Road	28.7	33.8	5.1	29.0	34.3	5.3
Banyan Road	10.4	11.6	1.2	10.5	11.5	1.0
Inverell Bay	33.5	34.5	1.0	38.6	39.1	0.5
Galupa	48.4	48.5	0.1	49.0	49.0	0
Ski Beach Clinic	24.0	24.9	0.9	28.4	28.7	0.3
Wallaby Beach	38.0	39.4	1.4	38.1	39.9	1.8

Table 7-1 indicates that the proposed expansion, as modelled, has very little impact on noise levels in the community. The increase in noise levels at all receivers is less than 1dB(A). Normally a 3 dB(A) increase is required to be significant. A 1 dB(A) increase is expected to be undetectable by residents.

The predicted future post–expansion noise levels comply with the proposed 'Background +3/5 dB(A) criteria' at Galupa and the noise levels at other receivers comply with the specified noise levels contained in the Regulation.

Impeller sirens are intermittent noise sources that operate for several minutes before the conveyor starts which only occurs a few times a week. As shown in Table 7-2, the noise impacts of impeller sirens at Inverell Bay, Galupa and Ski Beach Clinic are very minor as the noise levels at these locations elevate by less than 1 dB(A) when the sirens wail. The only area where impeller sirens have a greater impact are the southern part of Nhulunbuy. The noise levels from air-raid sirens are predicted to be 33-34dB(A) at Boxal Street and Enalu Road. At these levels, noise from impeller sirens comply with the specified noise levels contained in the Regulation and the sleep disturbance criteria.

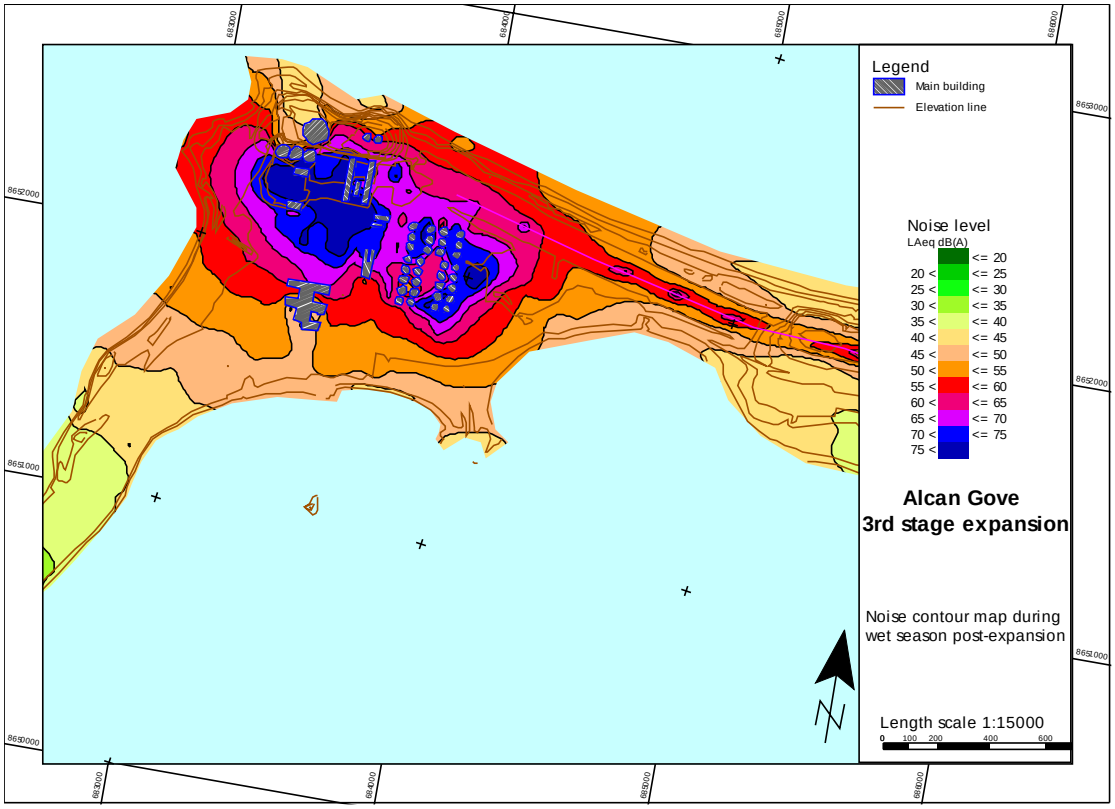


Figure 7-1: L_{Aeq} Noise contour map during wet season post expansion

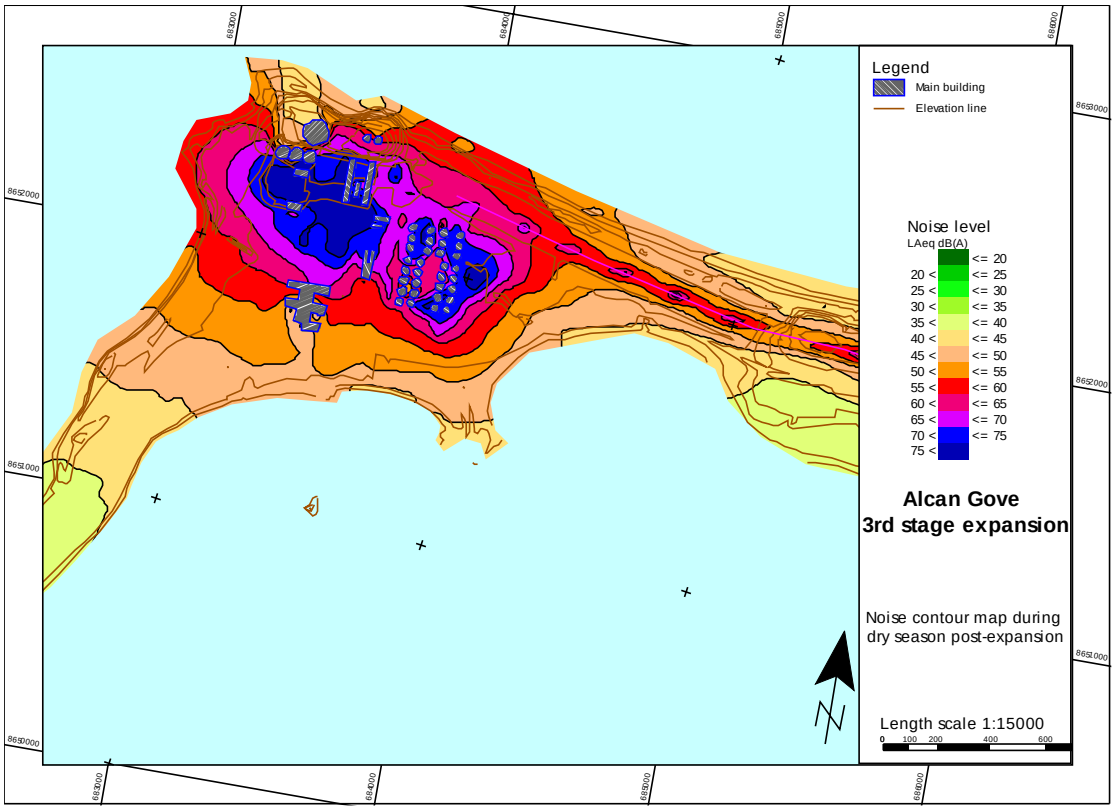


Figure 7-2: L_{Aeq} Noise contour map during dry season post expansion

7.1 Operational Road Traffic Impact

The refinery currently employ approximately 1,100 people. Assume 700 employees commute between Nhulunbuy and the refinery everyday and 400 of them travel by bus (Assume 5 to 35 people per bus), the current daily traffic volume going in and out of the refinery is approximately 700 vehicles per day.

Areas that are sensitive to traffic noise include Galupa and residences to the south of Melville Bay Road in Nhulunbuy. Wallaby Beach is not considered because this area will be vacates in the next few years. The distance between the closest residences in these areas and the road is approximately 20m. At this distance, with a daily traffic volume of 700 vehicles per day, the traffic noise levels is calculated to be $L_{A10(18\ hour)}$ 55dB(A).

At the residences to the south of Melville Bay Road in Nhulunbuy, the actual traffic noise levels could be higher due to other vehicles that travel to the industrial area and the airport.

After the expansion, there will be an additional 100 workers (Assume 50 by bus and 50 by car), which is equivalent to an additional 105 vehicles per day. This will increase the traffic noise level by 0.6dB(A) to 55.6 dB(A) at the closest residences to the road which complies with the $L_{A10(18\ hour)}$ 63dB(A) criterion. The increase is insignificant and no mitigation would be required.

7.2 Operational Ground Vibration

The operation will not include any significant ground vibration sources and there will therefore be no impact to sensitive receivers from the expansion.

8. CONSTRUCTION IMPACTS

8.1 Building Construction Noise

Building construction activity will be carried out at locations A-G in Figure 6-1. Construction works are expected to be carried out during daytime and early evening only (7am to 7pm). Galupa is the only community that is sensitive to construction noise.

Table 8-1 contains a list of typical of equipment likely to be operating during building construction. This table includes the predicted noise levels for each item of assessed equipment. Clearly the noisiest items are Jackhammers and pile hammers.

Table 8-1: Typical building construction equipment and predicted receiver noise levels

Item	L_{Amax} at 7m	Predicted L_{Amax} level at Galupa
Bulldozers	85 dB(A)	51dB(A)
Jackhammers	105 dB(A)	71 dB(A)
Compactors	85 dB(A)	51 dB(A)
Excavators	80 dB(A)	46 dB(A)
Trucks	83 dB(A)	49 dB(A)
Compressors	75 dB(A)	41 dB(A)
Pile Hammer	105 dB(A)	71 dB(A)
Concrete Pumps	84 dB(A)	50 dB(A)
Concrete Saws	93 dB(A)	59 dB(A)

* These predictions do not include additional attenuation from terrain shielding effects. It is likely that actual shielding effects will be in the order of 10 dB(A) to 15 dB(A) depending on the location of the construction activity. Therefore the predicted levels in this table are considered to be a conservative estimate of the noise at the sensitive receivers.

The majority of the building construction activity is likely to be at distances of 350 m or greater from Galupa. The predicted construction noise levels in Table 8-1 are less than the background noise levels at Galupa (~50 dB(A)) except for the Jackhammers, pile hammer and concrete saws. Therefore, most of the construction noise during the daytime is likely to be inaudible or faintly audible.

Under Northern Territory government's Draft Waste Management and Pollution Control (Environmental Noise) Regulation, Galupa is considered as "Area 5" in Table 4-1. The noise criteria for an Area 5 is L_{A10} 50dB(A), L_{A1} 60dB(A), L_{Amax} 70dB(A) between 7am to 7pm Monday to Saturday. Pneumatic rock breakers, pile hammers and concrete saws are intermittent noise sources which are best described by L_{A1} and L_{Amax} levels. The predicted L_{A1} and L_{Amax} noise levels from jackhammer and pile hammers are 71 dB(A) at Galupa which exceed the L_{A1} and L_{Amax} criteria by 11dB(A) and 1dB(A), respectively. However, building and terrain shielding effect are not considered which might further reduce the noise levels by 10 to 15dB(A), resulting compliance with these noise criteria.

Furthermore, construction noise impact can be mitigated by restricting the use of jackhammers, pile hammer and concrete saws to 9am to 5pm Monday and Saturday at construction areas that are close and have direct line of sight to Galupa.

8.2 Construction Ground Vibration

The proposed expansion is likely to have some minor localised vibration caused by use of heavy earth moving equipment and pile driving equipment. This vibration will however be negligible at the nearest sensitive receiver due to the large distance from the source.

No blasting is planned during construction.

8.3 Construction Road Traffic Noise

During the peak construction period, an additional 1200 people will be accommodated at Nhulunbuy and will be bussed to the site each day. Assume one 10 hour shift per day and there will be an additional 150 light vehicles visit and 80 extra truck trips per days, the daily traffic volume will be increased by approximately 230 per day. This will increase the traffic noise level by 1.7dB(A) to 56.7 dB(A) at the closest residences to the road which complies

with the $L_{A10(18\ hour)}$ 63dB(A) criterion. The increase is insignificant and no mitigation would be required.

9. NOISE MANAGEMENT PLAN

9.1 Construction

The following Noise Management Plan (NMP) will apply during the construction phase.

Summary of Impacts

The construction of the third stage expansion will potentially create noise impacts. Many construction activities and work practices result in high noise levels, however, due to the distance and buildings between residences and the construction area noise impacts shall be minimal if work is conducted during reasonable hours.

Objective

To minimise the generation of noise emissions during the construction and to mitigate any noise impacts.

Legislative Basis

Ensure that noise from the third stage expansion complies with the requirements of the Regulation

Performance Criteria

The following noise minimising practices from AS2436-1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites" are suggested:

- Where reasonably practicable, noisy plant or processes should be replaced by less noisy alternatives;
- Plant should always be used in accordance with the manufacturer's instructions;
- Care should be taken to site noisy equipment away from noise-sensitive areas;
- Where possible, loading and unloading should also be carried out away from noise-sensitive areas;
- Plant known to emit noise strongly in one direction should, where possible, be orientated so that the noise is directed away from noise-sensitive areas;
- Machines which are used intermittently such as cranes, dozers, grades, backhoes, bobcats, loaders, etc, should be shut down in the intervening periods between work or throttled down to a minimum;
- Where machines are fitted with engine covers, these should be kept closed when the machine is in use;
- Regular and effective maintenance of stationary and mobile equipment including off-site vehicles is essential and will do much to keep noise levels near to that of new machinery.

The following measures should be carried out:

- Construction work is to be carried out in accordance with Section 6 of AS2436;
- Equipment used on the construction site is to be the quietest reasonably available;
- Maintain up to date records on site of all noise complaints in the 'Environmental Incidents and Complaints Register';

- Should a noise complaints arise, noise monitoring or measurements may be required to determine the level of noise and decide on any ameliorative measures;
- Follow up justified complaints with a telephone call explaining the reason for the noise incident and the action taken;
- Maintain up to date records on site of all significant noise incidents in the 'Environmental Incidents and Complaints Register';
- Report to the Administering Authority, as soon as practicable, any significant incident which may give rise to complaint;
- Conduct internal, informal monthly audits on site of work practices and condition of equipment;
- All staff are to be trained to provide the standard of noise care expected in accordance with this EMP;
- All site equipment is to be maintained on a regular basis.

Monitoring

The construction supervisor will carry out or delegate the following monitoring activities:

- Noise monitoring should be conducted at residences from where complaints arise.

Reporting

The reporting requirements for the NMP during construction are as follows:

- Recording of any complaints regarding noise quality in a Complaints and Incidents Register;
- Recording of any negative noise impact incidents in a Complaints and Incidents Register;
- Reporting of above events to the Department of Business, Industry and Resource Development (DBIRD);
- Additional noise reports may arise if noise monitoring is conducted.

Corrective Actions

Recorded exceedances of the noise emission goals shall instigate the following actions:

- Meetings between the complainant and Project Community Liaison representative;
- Manned measurement of noise levels to determine activity causing excessive noise emission levels;
- If necessary, specialist consultants will be employed to determine adequate amelioration strategies.

9.2 Operation

The following NMP will apply to the third stage expansion project when the area is in operation.

Summary of Impacts

The third stage expansion in operation will create noise impacts. These noise impacts will include:

- noise from industrial buildings;
- noise from point sources located in the refinery (eg various plant items);
- noise from mobile sources (eg trucks, forklifts etc and noise from associated materials handling activities).

Objective

To ensure that any noise emissions from the third stage expansion while it is operating are of a reasonable level and any exceedances are dealt with quickly and effectively.

Legislative Basis

Ensure that noise from the third stage expansion complies with the requirements of the Regulation

Performance Criteria

The performance criteria seek to minimise the negative impacts of the third stage expansion. The following noise limits have been determined using the criteria specified in this report and the measured background noise levels.

Noise from the expanded refinery should not exceed the following limits at the following noise receptors

Table 9-1: Recommended Noise Limits (Excluding existing background noise level)

Noise receiving area	Time of day	L_{A10} dB(A)	L_{A1} dB(A)	L_{Amax} dB(A)
All sensitive receivers expect Galupa	7am to 7pm Mon-Sat	45	55	65
	9am to 7 pm Sunday & Public holiday	40	50	65
	7pm to 10pm all days	40	50	55
	10pm on any day to 7am Mon – Sat and 9am Sunday & public holiday	35	45	55

Table 9-2: Recommended Noise limits at Galupa (Including existing background noise level)

Noise Limit - $L_{Amax,adj}$		
Day (7am to 7pm)	**Evening (7pm - 10pm)**	**Night (10pm - 7am)**
55 dB(A)	55 dB(A)	53 dB(A)

Monitoring

The administering authority shall carry out or delegate the following monitoring activities:
Noise measurements should be conducted at nearby sensitive receivers to ensure that the above noise limits are being adhered to. Results should consist of a combination of manned and unmanned measurements. Noise measurements should be conducted within 6 months after the expansion and also when noise compliant is received. Exceedances should be noted and directed to the responsible authority.

Reporting

The reporting requirements for the NMP during the operation are as follows:

- Reporting of the noise measurement results 6 months after the expansion;
- Additional noise reports may arise if complaints are received.

Corrective Actions

Recorded exceedances of the noise emission limits shall instigate the following actions:

- Manned measurement of noise levels to determine activity causing excessive noise emission levels;
- If necessary, specialist consultants will be employed to determine adequate amelioration strategies.

10. CONCLUSION

Noise predictions indicate that the proposed expansion has very little impact on noise levels in the community. Increase in operational noise levels from the expanded refinery at all receivers is less than 1dB(A). The predicted future post–expansion noise levels comply with the proposed 'Background +3/5 dB(A) criteria' at Galupa and the noise levels at other receivers comply with the specified noise levels contained in the Regulation.

The noise impacts of impeller sirens at Inverell Bay, Galupa and Ski Beach Clinic are very minor as the noise levels at these locations increase by less than 1 dB(A) when sirens wail. The only area where conveyor start-up impeller sirens have a greater impact are the southern part of Nhulunbuy. The noise levels from impeller sirens are predicted to be 33-34dB(A) at Boxal Street and Enual Road. At these levels, noise from impeller sirens comply with the specified noise levels contained in the Regulation and the sleep disturbance criteria.

Road traffic noise during and after construction have been assessed and are found to comply with the $L_{A10(18\ hour)}$ 63dB(A) criterion. The increase is insignificant and no mitigation is required.

Construction noise from intermittent sources such as jackhammer and pile hammers may exceed the construction noise criteria at Galupa. The noise impact can be mitigated by restricting the hours for the use of Jackhammers, pile hammer and concrete saws at construction areas that are close and have direct line of sight to Galupa.

Construction is likely to cause some minor localised vibration due to use of heavy earth moving equipment and pile driving equipment. This vibration will however be negligible at the nearest sensitive receiver due to the large distance from the source.

The operation will not include any significant ground vibration sources and there will therefore be no impact to sensitive receivers from the expansion.

Overall, with the construction noise mitigation measures in place, the noise impact of the third stage expansion will be acceptable.