Appendix L

Environmental Noise Assessment

PACIFIC **ALUMINIUM**

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Katherine to Gove Gas Pipeline

Environmental Noise Assessment

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KATHERINE TO GOVE GAS PIPELINE
ENVIRONMENTAL NOISE ASSESSMENT

Rev	Description	Originator	Reviewer	WorleyParsons Approval	Date	Client Approval	Date
0	Issued for Client Use	AP Boladz	G Hickson	A J Wood	27-Mar-13		
1	Re- Issued for Client Use	AP Boladz	A Hanly	A J Wood	04-Apr-13		
2	Re-Issued for Client Use	AP Boladz	A Hanly	K Olson	29-Apr-13		

Executive Summary

Overview

The proposed Katherine to Gove Gas Pipeline (KGGP) project is a 603 km natural gas pipeline from a connection on the Amadeus Pipeline, approximately 20 km south of Katherine, to the alumina refinery located at Gove, north east Arnhem Land.

WorleyParsons were commissioned by Pacific Aluminium to undertake a noise and vibration assessment for inclusion in the environmental impact statement being completed for the project. The aims of the assessment are to assess the following at the nearest significant receptors:

- Noise and vibration impacts associated with the construction of the pipeline.
- Noise impacts associated with the operation of the pipeline.

Sensitive Receptors

The identified nearest potential known sensitive human receptors are as follows:

- Beswick Township which is a small community with numerous dwellings located on the Central Arnhem Highway approximately 1.5 km north of the proposed pipeline route.
- Nhulunbuy which supports the bauxite mine and alumina refinery the KGGP would supply gas to is located on the Gove peninsula at the northern tip of Arnhem Land with a population of approximately 3,800 permanent residents. It is located approximately 1 km north east of the proposed pipeline route.
- Bittitjimi which is a small community located west of Nhulunbuy on the Gove peninsula. It is located approximately 250 m north of the proposed pipeline route.
- Galupa which is a small community located south of the Gove Refinery on the Gove peninsula. It is located approximately 850 m south of the proposed pipeline route.

Applicable Criteria

The criteria that have been used to assess the noise and vibration levels at the sensitive receptors are as follows:

- Northern Territory Environment Protection Authority *Noise guidelines for development sites – In the Northern Territory.*
- Western Australia *Environmental Protection (Noise) Regulations 1997*. The Western Australian noise Regulations have been referenced as the Northern Territory legislation is not prescriptive in regards to the specific criteria for noise to be used in the implementation of the Environmental Protection objectives.
- British Standard 7385:Part 2-1993 *Evaluation and Measurement for Vibration in Buildings Part 2.*
- US Bureau of Mines, RI 8485-1980.
- Australian and New Zealand Environment Council (ANZEC) guidelines *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZEC guidelines) - 1990.

Modeling

The acoustic modeling program SoundPLAN was used to predict the noise levels at the receptors during the following construction activities:

- Clear and grade.
- Blasting preparation.
- Rock hammering.
- Trenching, trench breaking, stringing, bending and lowering of pipes.
- Welding and joint coating.
- Hydrotesting, dewatering and drying.
- Padding, shading and backfilling.
- String and pit tie ins and road crossings.
- Restoration and rehabilitation.
- Commissioning.

Noise levels were predicted for the operational phase using distance attenuation calculations to establish predicted noise levels at different distances from the compressor station and pressure regulating facility. Noise levels were also predicted at sensitive receptors for planned maintenance at all facilities.

All sound power levels used in the modeling were indicative of plant items and it is recommended that a verification exercise is carried out following the detailed design.

The blasting site laws were based on the generic ground vibration and airblast formulae presented in Australian Standard AS 2187 (also known as the ICI formulae) for blasting in 'hard or highly structured rock'.

Construction Noise Assessment

The predicted noise levels at the receptors at Beswick, Nhulunbuy and Galupa for all construction activities were found to be compliant with the day time criteria contained within the construction guidelines.

The predicted noise levels at the receptors within Birritjimi due to their proximity to the proposed pipeline route exceed the criteria contained within the construction guidelines for the following scenarios:

- Rock hammer.
- Trenching, trench breaking, stringing, bending and lowering the pipe.

In order to reduce the impact from construction noise at Birritjimi from these activities, a number of recommendations have been made for consideration.

Hydrotesting at night was identified to potentially exceed the acceptable criteria at night time in the vicinity of Nhulunbuy, Birritjimi and Galupa. However, the plant associated with this activity can be placed at fill points along the pipeline to ensure that they do not have an impact on these receptors. It is therefore recommended that fill points for hydrotesting are located at least 2 km from a nearby receptor so as not to cause a night time noise impact.

A qualitative assessment of noise from traffic was made and it was anticipated that as along as peak construction traffic volumes occur around 6.00 am and 6.00 pm adverse community reaction is unlikely.

Adherence to the noise criteria at sensitive receptors will be managed through the development of a noise management plan. The noise management plan will cover the mitigation strategies for activities close to Birritjimi, construction traffic and night time construction activities (hydrotesting) due to the potential for noise impact at Nhulunbuy, Galupa and Birritjimi. The noise management plan will also detail complaint management procedures and community consultation strategies.

Operational Noise Assessment

Due to the large separation distances between the compressor station / pressure regulating facility and the nearest receptors the predicted noise levels during operation are within the criteria contained within the noise Regulations.

The predicted noise levels from planned maintenance activities at the nearest noise sensitive receptors were also assessed and were found to exceed the noise Regulations in the following instances:

- The blowdown exceeds the day time criteria, evening criteria and the night criteria at Nhulunbuy.

The predicted noise levels for this assessment were based on estimated Sound Power Levels Therefore it is recommended that they be reviewed once the detailed design is complete.

Vibration (Blasting) Assessment

The estimated ground-borne vibration and airblast levels were predicted based on the maximum instantaneous charge and were found to comply with the recommended levels, and therefore the potential vibration impact of the project on receptors is considered to be low.

Contents

1 INTRODUCTION

The proposed Katherine to Gove Gas Pipeline (KGGP) project is a 603 km natural gas pipeline from a connection on the Amadeus Pipeline, approximately 20 km south of Katherine, to the alumina refinery located at Gove, north east Arnhem Land.

WorleyParsons were commissioned by Pacific Aluminium to undertake a noise and vibration assessment for inclusion in the environmental impact study being completed for the project. The aims of the assessment are to assess the following at the nearest significant receptors:

- Noise and vibration impacts associated with the construction of the pipeline.
- Noise impacts associated with the operation of the pipeline.

The requirements of the noise assessment are defined in the Northern Territory Environment Protection (NT EPA) document *Guidelines for the preparation of an environmental impact statement – Katherine to Gove Pipeline* (the guidelines) dated January 2013.

The key noise issues identified in the guidelines are:

- Identification of receptors adjacent to the pipeline route and relevant ancillary activities such as compressor stations.
- Investigation of typical background noise levels.
- Discussion regarding potential sensitivity of receptors to noise and vibration.
- Address the impact of noise and vibration on residents.
- Production of a Noise Management Plan (NMP), this is not covered in this report. The NMP will be a stand-alone document.

2 BACKGROUND

2.1 Project Description

Pacific Aluminium (a business unit of Rio Tinto) owns and operates a bauxite mine and alumina refinery at Gove, 650 kilometres (km) east of Darwin in north east Arnhem Land, Northern Territory. The Gove mine and refinery produce high grade alumina which is then shipped to other locations for smelting and further processing.

Power and steam for the Gove Refinery and mining operations are currently generated from imported fuel oil. In order to reduce fuel oil consumption and improve operating costs at the Refinery, it is proposed to provide the facility with natural gas as an alternative fuel source. The lower cost natural gas will help underpin the long term operating viability of the Refinery.

The Katherine to Gove Gas Pipeline (KGGP) is proposed to deliver natural gas from the existing NT Amadeus Gas Pipeline at a point approximately 20 km south of Katherine, to the Gove Refinery. The KGGP would be a high pressure, steel pipeline approximately 603 km long with a nominal diameter of 300mm and a design operating life of 50 years.

It will also include above ground facilities at specific locations along the route such as metering facilities, scraper stations, mainline valves and a compressor station. The supplied gas from the Amadeus Pipeline is sales quality so no additional processing of gas would be required.

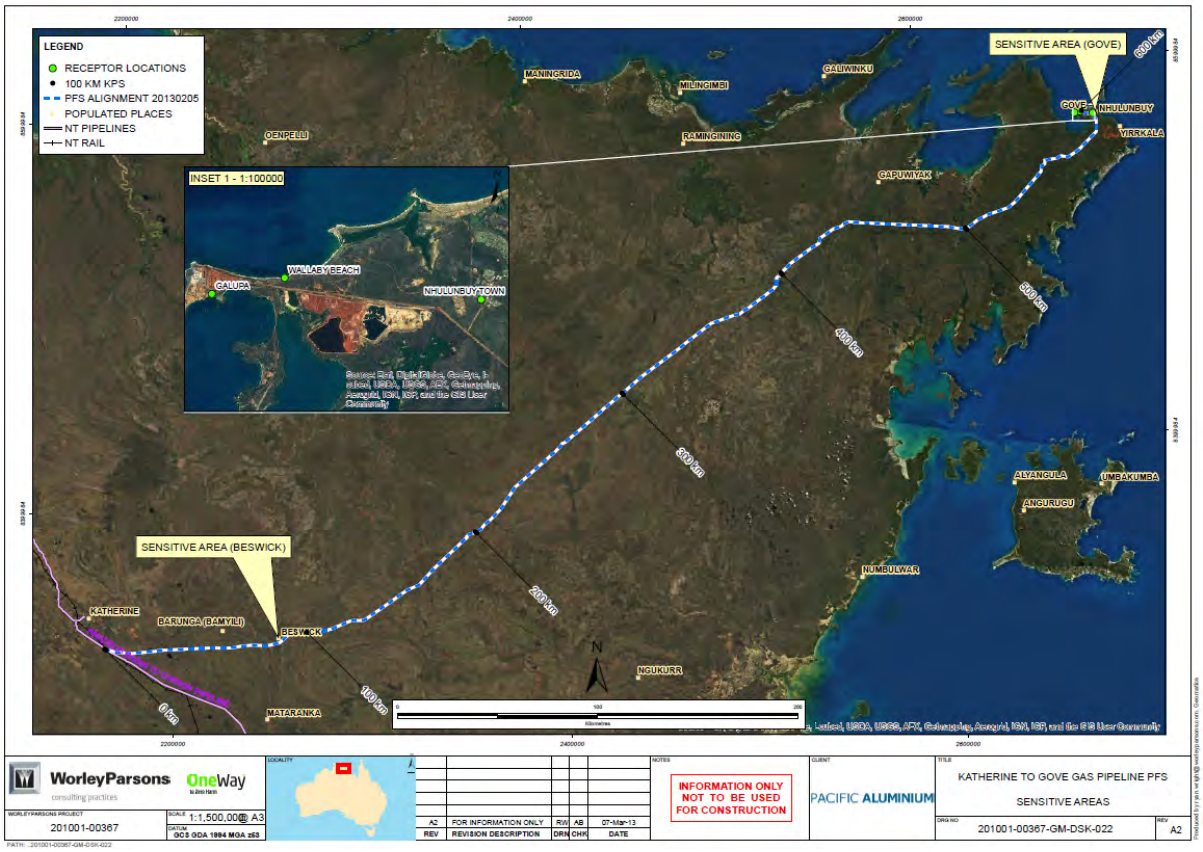
The pipeline would be constructed within a 30 m wide construction corridor and would include supporting infrastructure such as temporary work camps and equipment access tracks to facilitate construction activities.

The construction corridor and trench for the KGGP would be prepared using graders, backhoes, bulldozers, excavators, trenching machines, rock saws and drilling and blasting. The proposed route would cross several watercourses, roads and infrastructure corridors. Proposed specialised techniques for installing the pipeline at these locations include open-cut and horizontal directional drilling.

The location of the pipeline is shown in

Figure 2-1.

Figure 2-1 Location of Pipeline and Sensitive Receptors



2.2 Location of Sensitive Receptors

The nearest potential known sensitive human receptors were identified using aerial imagery of the pipeline route, review of the July 2004 report *Trans Territory Pipeline Project – Environmental Noise Assessment* by Air Noise Environment Pty Ltd (Air Noise Environment report) and of the *Rio Tinto Alcan Gove Noise and Vibration Investigation* produced by Vipac Engineers & Scientists Ltd in 2009 (Vipac Report). The following sensitive human receptors were identified within 2 km of the proposed pipeline route (see

Figure 2-1):

- Beswick Township which is a small community with numerous dwellings located on the Central Arnhem Highway approximately 1.5 km north of the proposed pipeline route.
- Nhulunbuy which is a mining town located on the Gove peninsula at the northern tip of Arnhem Land with a population of approximately 3,800 permanent residents. It is located approximately 1 km north east of the proposed pipeline route.
- Birritjimi which is a small community located west of Nhulunbuy on the Gove peninsula. It is located approximately 250 m north of the proposed pipeline route.
- Galupa which is a small community located south of the Gove Refinery on the Gove peninsula. It is located approximately 850 m south of the proposed pipeline route.

There are other potentially sensitive receptors outside of 2 km, however the modeling shows that noise levels will be within guideline limits at these distances and so they were not considered for assessment.

Smaller receptors may not have been identified during the desktop study due to the limitations of using aerial imagery. If receptors are identified closer to the pipeline than the above receptors further modeling should be carried out to ascertain the likely noise levels at these locations.

3 ASSESSMENT CRITERIA

3.1 Noise Criteria

Under the Northern Territory Government Legislation environmental noise (inclusive of vibration) is considered a form of pollution and it is regulated under the *Waste Management and Pollution Control Act* (the Act) as in force 1 January 2013. The objectives of the Act are:

(a) To protect, and where practicable to restore and enhance the quality of, the Territory environment by:

(i) preventing pollution;

(ii) reducing the likelihood of pollution occurring;

(iii) effectively responding to pollution;

(iv) avoiding and reducing the generation of waste;

(v) increasing the re-use and re-cycling of waste; and

(vi) effectively managing waste disposal;

(b) to encourage ecologically sustainable development; and

(c) to facilitate the implementation of national environment protection measures made under the National Environment Protection Council (Northern Territory) Act. The objectives of the *Waste Management and Pollution Control Act* are implemented by Environmental Protection Objectives whose purpose is to establish the principles on which:

(a) *environmental quality is to be maintained, enhanced, managed or protected;*

(b) pollution, or environmental harm resulting from pollution, is to be assessed, prevented, reduced, controlled, rectified or cleaned up; and

(c) effective waste management is to be implemented or evaluated.

The Act is not prescriptive in regards to the specific criteria to be used in the implementation of the Environmental Protection objectives. As a result noise and vibration criteria from guidance documents, national or international standards or from environmental legislation in other States in Australia are used in specific acoustic investigations.

In this case the assigned noise levels contained within the Western Australian (WA) *Environmental Protection (Noise) Regulations 1997* (the noise Regulations) are considered the most appropriate noise criteria. The assigned levels within the noise Regulations are well established and tested on numerous infrastructure projects within north Western Australia which has an environment similar to the Northern Territory.

3.1.1 Construction Noise

The Northern Territory Environment Protection Authority (NT EPA) produce guidance on noise from construction activities in their *Noise guidelines for development sites – In the Northern Territory* (the NT EPA construction guidelines) dated January 2013.

These guidelines are used to protect noise sensitive receptors and minimise issues arising from construction noise by:

- Assisting the NT EPA in its assessment of Development Applications by the application of these guidelines.
- Advising those responsible for development sites of their obligations in managing construction noise at their sites.
- Informing when noise generated by an activity may be considered an environmental nuisance, and how registered Noise Management Plans may be used to resolve noise issues.
- Assisting Authorised Officers under the Act, to determine if a breach of the Act has occurred.
- Providing advice on what a person should do if they become aware of construction noise that may be causing or has the potential to cause an environmental nuisance.

The NT EPA construction guidelines advise that construction activities should be restricted to:

- Between 7 am and 7 pm Monday to Saturday.
- Between 9 am and 6 pm on a Sunday or public holiday.

Construction noise levels within 15 m of a noise sensitive receptor or at or on the boundary of the noise sensitive receptor (adjusted for tonality, impulsiveness and/or modulation) during acceptable construction times should not exceed the following L_{Aeq} noise limits:

- Residential areas ambient noise plus 5 dBA.
- Mixed commercial/residential areas 60 dBA.
- Commercial areas 65 dBA.
- Industrial areas 70 dBA.

The *Waste Management and Pollution Control Act* defines noise that affects the amenity of an area as an 'environmental nuisance'. Noise from a development site may be considered an environmental nuisance and may be considered an offence under the Act.

Noise emitted from a development site may be considered an environmental nuisance or pollution if:

a) The construction activity is conducted:

   i. outside the hours of 7 am and 7 pm Monday to Saturday; or

   ii. on a Sunday or public holiday outside the hours of 9 am and 6 pm; and

b) The construction activity was not carried out in accordance with 'Australian Standard AS 2436 *Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites'*; and

c) 48 hours' notice was not given to the occupiers of all noise-receiving premises where noise levels for the development site are likely to be of concern including:

   i. A description of proposed construction activity likely to cause a nuisance.

   ii. The time(s) and date(s) for the construction activity.

   iii. The name and phone number of the person to whom a complaint may be made about noise emissions from the site.

Or

d) The activity was not carried out in accordance with a NMP registered with the NT EPA.

If noise resulting from a construction activity is to be emitted from a development site:

   i. Outside the times 7 am to 7 pm Monday to Saturday; or

   ii. Outside the times 9 am to 6 pm on a Sunday or public holiday; or

   iii. Is likely to exceed the construction noise levels defined in these guidelines; and

   iv. The construction work is proposed, or taking place on, land within or directly adjacent to land zoned Commercial or Residential.

The party responsible for the development site must develop and register a NMP with the NT EPA. NMPs should comply with 'AS 2436: *Guide to Noise and Vibration Control on Construction, Maintenance and Demolition Sites*'.

A NMP must include management and mitigation strategies to prevent an environmental nuisance caused by construction noise.

Based on the ambient noise levels obtained from the background noise monitoring detailed in **Section 4** the specific noise criteria for the construction impacts during the daytime only are shown in **Table** 3-1. In order to assess night time noise impacts as the NT EPA construction guidelines have no night time criteria the noise Regulations have been referenced.

Table 3-1 Specific Construction Noise Criteria

Type of Receptor	L_{Aeq}(15minute) Construction Noise Management Level dBA			
	Beswick	Nhulunbuy	Birritjimi	Galupa
Residential	54	67	65	67
Mixed Commercial/Residential	60	60	60	60
Commercial	65	65	65	65
Industrial	70	70	70	70

Note that due to high ambient noise levels measured within the Gove Peninsula that the criteria for the residential receivers is higher than that for a commercial receiver.

3.1.2 Operational Noise

The Western Australia noise Regulations require that noise emitted from any premises must comply with assigned noise levels when received at any other premises and be free of the intrusive characteristics of tonality, modulation and impulsiveness. In addition, the noise emissions must not "significantly contribute" to an exceedance of the assigned levels.

The assigned levels are specified according to the type of premises receiving the noise. For noise sensitive receptors, the assigned levels recognise the time of day and the presence of commercial and industrial land zonings and major roads within a 450 m radius of the receptor. The noise Regulations specify requirements relating to tonality, modulation and impulsiveness, as well as to emissions that may "significantly contribute" to an exceedance.

Assigned Noise Levels

Assigned noise levels are the levels of noise allowed to be received at premises at a particular time of the day.

There are different assigned levels for noise sensitive, commercial and industrial premises. The assigned levels for noise sensitive premises vary depending on the time of the day. The assigned levels also depend on how close the noise sensitive premises are to industrial and commercial areas and to major roads. The assigned noise levels always apply at the premises receiving the noise.

A noise emission is generally understood to "significantly contribute" if it is higher than a level which is 5 dBA (decibels) below the assigned level at the point of reception.

The table of assigned levels, shown in **Table** 3-2, identifies three types of assigned levels: L_{Amax}, L_{A1} and L_{A10}.

Table 3-2 Table of Assigned Noise Levels

Type of premises receiving noise	Time of day	Assigned level dB		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15 m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + influencing factor[1]	55 + influencing factor[1]	65 + influencing factor[1]
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor[1]	50 + influencing factor[1]	65 + influencing factor[1]
	1900 to 2200 hours all days	40 + influencing factor[1]	50 + influencing factor[1]	55 + influencing factor[1]
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + influencing factor[1]	45 + influencing factor[1]	55 + influencing factor[1]
Noise sensitive premises at locations further than 15 m from a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

1 The "influencing factor" is calculated for each noise-sensitive premises receiving noise. It takes into account the amount of industrial and commercial land and the presence of major roads within a 450 m radius around the noise receptor.
The "influencing factor" will range from zero to about 20 in most cases.

The influencing factor (IF) increases with the amount of commercial and industrial premises in the vicinity of the receptor as well as the presence of major or minor roads. This is calculated by considering areas within 100 m and 450 m of the receptor. In this instance there is no IF correction for the proposed project impact assessment for the receivers at Beswick, Nhulunbuy and Birritjimi. However, the receptors located at Galupa have an IF of 6 dB to be added to their respective assigned levels due to the presence of the Gove Refinery within 450 m.

If noise emitted from any premises when received at any other premises cannot reasonably be free of the intrusive characteristics of tonality, modulation and impulsiveness, then a series of adjustments must be added to the emitted levels (measured or calculated) and the adjusted level must comply with the assigned level. The adjustments are detailed in

Table 3-3.

Table 3-3 Table of Adjustments

Adjustment where noise emission is not music these adjustments are cumulative to a maximum of 15 dB		
Where tonality is present	**Where modulation is present**	**Where impulsiveness is present**
+5 dB	+5 dB	+10 dB

3.1.3 Noise Impact on Wildlife

Literature discussing the effects of noise on birds generally focuses on environments where chronic noise has caused vacation from an area over time due to the inability of some species to adequately communicate above ambient noise levels (e.g. in busy urban areas or near to large industries). As far as our research has revealed, there are no government policies or other widely-accepted guidelines in respect to the noise levels which may be acceptable to wildlife. The levels or character of noise that may "startle" or otherwise affect the feeding or breeding pattern of birds or other animals are also not firmly established in the technical literature.

A computer-based literature search of DIALOG and other scientific databases has been conducted. In an earlier attempt to determine the levels of acceptable noise exposure for wetland birds and other animals, we also contacted the National Parks and Wildlife Service and a set of possibly relevant technical references was supplied.

After review of these references, and particularly a paper by the NSW Department of Agriculture and Fisheries (Poole 1982[1]) and a study by the Swedish University (Algers *et al* 1978[2]) on the effects of continuous noise on animals, it is concluded that birds tend to accept and/or adapt to constant steady noise levels, even of a relatively high level in the order of 70 dBA. Poole found that continuous exposure to higher noise levels (from 70 dBA to 85 dBA and above) may cause some degree of behavioural changes in birds, non-specific to species. Observations of behaviour patterns also indicate a higher tolerance to intermittent, moderate level noise events such as road traffic. Sudden loud or impulsive or impact noises are capable of causing birds and other wild animals to become startled, which if repeated in the longer term, may affect feeding and possibly breeding habits in some bird species. On the other hand, there are instances where such noises have been used in an attempt to drive flocks of birds (and bats) away from particular sites (airports, waste disposal sites, etc.). Due possibly to the more "domesticated" nature of these bird species, the success of such trials have been limited.

[1] Poole G, 1982. *Sound Advise Poultry Notes*. NSW Department of Agriculture and Fisheries.
[2] Algers B, Ekesbo I, Strombery S, 1978. *Noise Measurement in Farm Animal Environments*. ACTA Veterinaria Scandinavica. Suppl.68, p19.

3.2 Vibration Criteria

3.2.1 Ground Vibration - Structural Damage Criteria

The British Standard 7385:Part 2-1993 *Evaluation and Measurement for Vibration in Buildings Part 2* is a definitive standard against which the likelihood of building damage from ground vibration can be assessed. This is the Standard recommended in Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use – Part 2: Use of Explosives* as the guideline values and assessment methods "are applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration which are considered in the standard include blasting (carried out during mineral extraction or construction excavation), demolition, piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

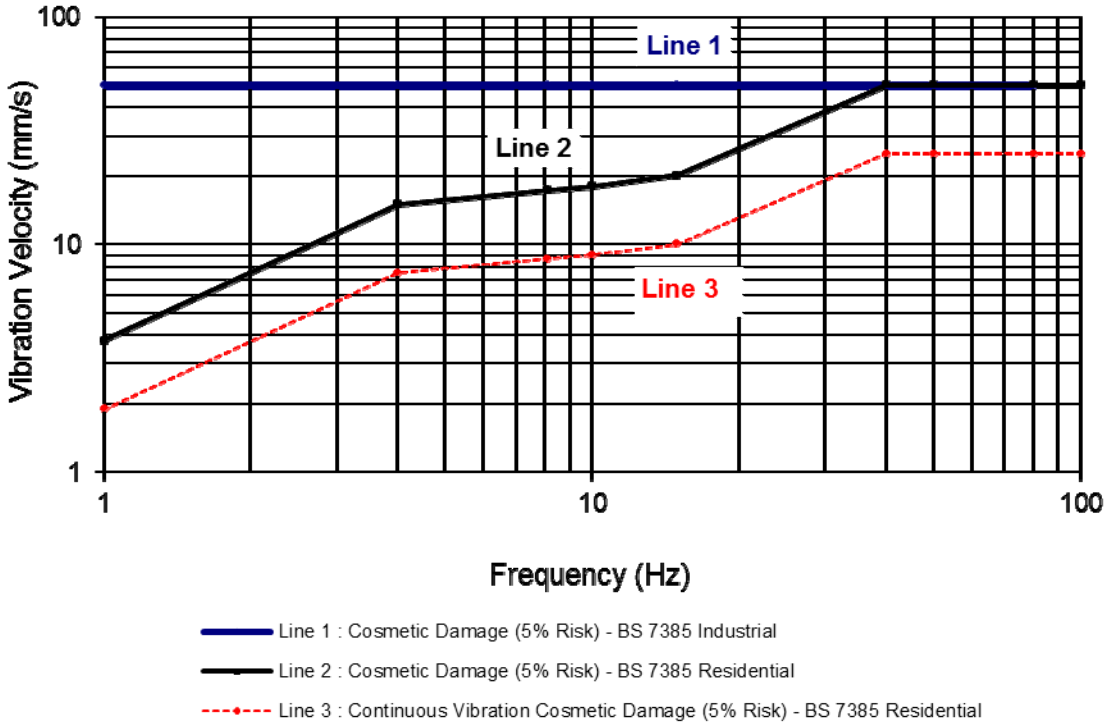
The guide values from this standard for transient vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in **Table** 3-4 and graphically in **Figure** 3-1.

Table 3-4 Transient Vibration Guide Values for Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher the guide values for the building types corresponding to Line 2 in **Figure** 3-1 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

Figure 3-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table** 3-4 and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table** 3-4 should not be reduced for fatigue considerations.

It is noteworthy that extra to the guide values nominated in **Table** 3-4, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

3.2.2 Airblast - Structural Damage Criteria

Based largely on work carried out by the US Bureau of Mines, the US Office of Surface Mining has presented the following regulatory limits for airblast from blasting (depending on the low frequency limit of the measuring system).

Low Frequency Limit	Peak Airblast Level Limit
2 Hz or lower	132 dB Linear
6 Hz or lower	130 dB Linear

These levels are generally consistent with the level of 133 dB Linear nominated in AS 2187.2-2006.

The US criteria are structural damage limits based on relationship between the level of airblast and the probability of window breakage and include a significant safety margin. It has been well documented that windows are the elements of residential buildings most at risk to damage from airblast from blasting.

While cracked plaster is the type of damage most frequently monitored in airblast complaints, research has shown that window panes fail before any other structural damage occurs (USBM, RI 8485-1980). The probabilities of damage to windows exposed to a single airblast event are as shown in **Table** 3-5.

Table 3-5 Probability of Window Damage from Airblast

Airblast dB Linear	Level kPa	Probability of Damage	Effects and Comments
140	0.2	0.01%	“No damage” - windows rattle
150	0.6	0.5%	Very occasional failure
160	2.0	20%	Substantial failures
180	20.0	95%	Almost all fail

Human Comfort and Disturbance Considerations

The ground vibration and airblast levels which cause concern or discomfort to residents are significantly lower than the damage limits. Humans are far more sensitive to some types of vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents.

The airblast criteria normally recommended for blasting in Western Australia is based on the human discomfort criteria incorporated within the noise Regulations.

For groundborne vibration (which is not stipulated in the *Environmental Protection (Noise) Regulations 1997*), the use of the Australian and New Zealand Environment Council (ANZEC) guidelines *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (ANZEC guidelines) is a reasonable criterion for assessment purposes.

The relevant criteria for airblast are presented in **Table** 3-6, whist the vibration limits are discussed below:

- The recommended maximum peak particle velocity (ppv) level for ground vibration for residential properties is 5 mm/s.

- The ppv level of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 10 mm/s at any time.

It is recommended that blasting should generally only be permitted during the hours of 0900 hours to 1700 hours Monday to Saturday and that blasting should not take place on Sundays and public holidays. However, given the substantial offset distances to the nearest residences in remote locations, if blasting could be designed so as to achieve the airblast limits (refer **Table** 3-6), the resulting ground-vibration could be close to an order of magnitude or so below the criterion, and is therefore likely to be considered acceptable.

Table 3-6 Airblast Limits - Environmental Protection (Noise) Regulations 1997

	Monday to Friday	**Sundays and Public Holidays**	**Other times**
	7:00 am to 6:00 pm	**7:00 am to 6:00 pm**	**6:00 pm to 7:00 am**
Peak limit from ANY blast	125 dBL	120 dBL	90 dBL
Peak limit for 9 of 10 consecutive blasts	120 dBL	115 dBL	-

4 EXISTING ENVIRONMENT

Background noise monitoring has previously been carried out by Air Noise Environment as part of the noise assessment undertaken for the Draft EIS for the Trans Territory Pipeline project. Vipac Engineers and Scientists have also undertaken background monitoring for the Gove refinery. On examination of their methodology and results, and taking into account the rural nature of the area surrounding the proposed pipeline; it is considered that the noise levels presented in these reports are relevant to this study without the need for any further background monitoring.

The background noise monitoring by Air Noise Environment was undertaken between 2 – 4 June 2004 at the following locations:

- Remote bushland which is representative of the existing noise levels at Beswick.
- Wadeye Township which is not applicable to this assessment.

The results of the noise monitoring within the area representative of Beswick are shown in **Table** 4-1.

Table 4-1 Average Measured Background Noise Levels

Monitoring Location	Period	Noise Levels dB			
		Average[1] L_{A90}	Average[1] L_{A10}	Average[1] L_{AEQ}	Average[1] L_{Amax}
Remote bushland	Day	34	42	49	64
	Evening	30	34	37	47
	Night	28	32	34	43

[1] The monitoring data was not complete for 3/6/04 and 4/6/04 therefore the two days were combined to produce an average one day measurement.

The background noise monitoring by Vipac Engineers and Scientists was undertaken between 26 – 30 April 2009 at the following locations relevant to this assessment:

- Birritjimi.
- Galupa.
- Nhulunbuy Town.

The results of the noise monitoring at these locations are shown in

Table 4-2.

Table 4-2 Average Measured Background Noise Levels

Monitoring Location	Period[1]	Noise Levels dB			
		Average L_{A90}	Average L_{A10}[2]	Average L_{AEQ}	Average L_{Amax}
Birritjimi	Day	44	N/A	60	71
	Evening	43	N/A	50	64
	Night	39	N/A	47	60
Galupa	Day	44	N/A	62	81
	Evening	35	N/A	57	78
	Night	34	N/A	51	65
Nhulunbuy Town	Day	44	N/A	62	81
	Evening	35	N/A	57	78
	Night	34	N/A	51	65

[1] Periods relate to Daytime 7 am to 6 pm, Evening 6 pm to 10 pm and night time 10 pm to 7 am.
[2] No average LA10 available for these periods.

5 METHODOLOGY

5.1 Noise Modeling

The model was prepared using the SoundPLAN 7.1 Industrial Module a commercial software system developed by Braunstein and Bernt Gmbh in Germany.

The software allows the use of various internationally recognised noise prediction algorithms. The CONCAWE method, developed in The Netherlands for assessment of large industrial plants, has been selected for this assessment as it enables meteorological influences to be assessed.

The SoundPLAN model included the climatic parameters outlined in the Western Australia Environmental Protection Authority *Guidance for the Assessment of Environmental Factors Environmental Noise*, *Draft No.8*; these parameters are highlighted in **Table** 5-1. The modeling assumed a worst case scenario wind direction of from the source to the receptor. It is considered that the Western Australian parameters are appropriate in this circumstance due to the similar weather conditions in north Western Australia and the Northern Territory.

Topography for the areas around the sensitive receptors were inputted into the model and soft ground absorption was assumed in the modeling. Where there were surrounding buildings present as in the case of the Galupa scenario these were also included in the model, as no building height data was available for the refinery all buildings and structures were assumed to be 6 m high which is the standard building height within SoundPLAN.

Table 5-1 Meteorological Conditions Used In the Noise Predictions

Time of Day	Temperature	Relative Humidity	Wind Speed *	Pasquil Stability Category
Day (07:00 to 19:00)	20°C	50%	4 m/s	E
Night (22:00 to 07:00)	15°C	50%	3 m/s	F

* - The wind is orientated so that it blows from the source to the receptor

Source Sound Power Levels

The potential for machinery to emit noise is quantified as the Sound Power Level (SWL) expressed in A-weighted decibels (dBA). At the receptor, the received noise is quantified as the sound pressure level (SPL) expressed in dBA re 20 µPa. The SWLs used in the modeling are shown in

Table 5-2 these noise levels are sourced from WorleyParsons' extensive database of measurements of different plant and also with reference to the previous Air Noise Environment Report. The SWLs used are indicative of the chosen plant items for this project and it is recommended that a verification exercise is carried out following the detailed design.

Table 5-2 Source Sound Power Levels

Source Item	Octave Band Sound Power Level dBL									Total dBA
	31.5	63	125	250	500	1k	2k	4k	8k	
D9 Dozer	127	115	122	115	114	112	109	104	97	117
Grader	112	122	118	117	108	111	107	103	93	115
Light Vehicle	76	86	81	84	81	80	77	70	63	84
Rock Drill	105	107	118	112	108	108	105	98	92	113
Drill Rig	105	107	118	112	108	108	105	98	92	113
Stone Saw	108	109	114	112	111	114	113	107	98	118
Bucket Wheel Trencher	123	114	117	113	112	109	103	107	114	117
Vermeer Rock Saw	110	111	116	113	111	116	115	112	100	120
Excavator	97	112	106	102	102	101	97	87	77	105
Extendable Semi Trailer	112	120	112	112	108	105	103	98	91	111
Vaculift	120	120	119	115	115	112	108	99	89	117
2.5t Flatbed	111	119	111	111	107	104	102	97	90	110
Diesel Driven Hydraulic Bending Machine	112	116	123	120	114	108	107	102	98	117
Sideboom Tractor	107	112	117	116	115	113	108	102	98	117
Diesel Generator	98	102	109	106	100	94	93	88	84	103
Diesel Welding Machine	75	89	95	94	101	103	103	96	90	108
Diesel Air Compressor	106	102	98	93	90	86	86	79	72	93
Diesel Genset	98	102	109	106	100	94	93	88	84	103
Diesel Centrifugal Fill Pump	103	107	114	111	105	99	98	93	89	108
Diesel Refrigeration Drier	112	116	113	120	114	108	107	102	98	116
Ozzie Padding Machine	114	117	116	115	114	13	111	107	100	116
Tractor	95	95	106	102	102	102	98	92	85	106
Nitrogen Tanker and Vaporiser	121	129	121	121	117	114	112	107	100	120
Crane	108	108	107	103	103	100	96	87	79	105

5.2 Noise Modeling Scenarios

5.2.1 Construction Phase

For the purposes of assessing the noise impacts of the construction of the pipeline the scenarios within **Table** 5-3 were considered. It is assumed that the detailed plant would be required for the works within the vicinity of all of the identified receptors unless otherwise stated. The scenarios are indicative of the likely works to be undertaken.

The plant items for each construction scenario were placed along a maximum 500 m length of the nearest pipeline location to the identified receptors; the placement of each different plant item along the chosen pipeline location in the scenarios was different at each receptor location.

Table 5-3 Noise Modeling Scenarios

Scenario	Description	No. of Plant Items	Plant Type
Clear and grade	Corridor clearance 30 m wide of heavy vegetation. Topsoil stripped.	1	D9 Dozer
		1	Grader
		1	Light Vehicle
Blasting preparation	Blasting may be carried out in high rock areas. No blasting within Gove.	1	Rock Drill
		1	Drill Rig
		1	Light Vehicle
Rock hammering	Rock hammering at Gove	1	Stone Saw
		2	Rock Drill
Trenching, trench breaking, stringing, bending and lowering pipe.	Excavation of trench. Bending of pipes along laydown area. Lowering of pipes using sideboom.	1	Bucket Wheel Trencher
		1	Vermeer Rock Saw
		2	Excavator
		15	Extendable Semi Trailer
		1	Vaculift
		2	Light Vehicle
		1	2.5t Flatbed
		1	Diesel Driven Hydraulic Bending Machine
		1	Sideboom Tractor
		1	Diesel Generator
Welding and joint coating	Pipe sections welded together joints are grit blasted.	2	Sideboom Tractor
		8	Diesel Welding Machine
		2	Diesel Air Compressor
		1	Diesel Genset
		1	2.5t Flatbed
		1	Diesel Generator

Hydrotesting, dewatering and drying.	Pipeline pressure tested using water. Water moved or disposed and pipeline dried.	1	Diesel Centrifugal Fill Pump
		2	Diesel Air Compressor
		1	Extendable Semi Trailer
		1	Diesel Generator
		1	Diesel Refrigeration Drier
Padding, shading and backfilling.	Trench padded with sand, trench is backfilled and soil compacted.	2	Padding Machine
		1	Light Vehicle
		1	D9 Dozer
		1	Grader
String and pit tie ins and road crossings.	Joining together of strings and where route crosses a road.	2	Sideboom Tractor
		3	Excavator
		4	Diesel Welding Machine
		2	Diesel air compressor
		1	Diesel generator
Restoration and rehabilitation	Topsoil and vegetation is spread back over corridor.	1	Dozer
		1	Grader
		1	Tractor
Commissioning	Pipeline filled with nitrogen and then gas.	1	Nitrogen tanker and vaporiser
		1	2.5t Flatbed

Construction Traffic

The majority of access points for construction traffic to the pipeline are via roads with current low traffic volumes or with no data available on the traffic volumes, the most utilised roads used by construction traffic that pass significant potential sensitive receptors will be:

- Stuart Highway through Katherine.

The highest recorded traffic flow (2011) along the section of Stuart Highway that will be used by construction traffic and passes through Katherine was 2,282 vehicles per day. The anticipated construction traffic volume along the route will be an additional 65 vehicles per day.

- Central Arnhem Road passing Barunga.

The highest recorded traffic flow (2011) along the section of Central Arnhem Road that will be used by construction traffic was 157 vehicles per day. The anticipated construction traffic volume along the route will be as high as an additional 281 vehicles per day.

- Melville Bay Road through Nhulunbuy.

There are currently no existing traffic counts for Melville Bay Road. The nearest traffic count data (2011) is for Central Arnhem Road (which connects to Melville Bay Road) at the intersection with Dhupuma Road which is 66 vehicles per day. It is assumed that as Melville Bay Road is located near to an urban area that it would have a greater traffic flow than this. The anticipated construction traffic volume along this route will be 145 vehicles per day.

Due to the low traffic volumes on Central Arnhem Road and Melville Bay Road and also the small increase of traffic on Stuart Highway it is not appropriate to model noise emissions using the CoRTN road traffic noise model. However, because of the low current traffic volumes involved, but significant increase in traffic from the construction activities at Burunga and Nhulunbuy, a qualitative assessment of noise impacts will be made, for completeness Katherine will be included in this assessment.

The hours of operation for the pipeline construction activities in **Table** 5-3 are between 7 am and 5.30 pm, with occasional night work for specific operations such as hydrostatic testing. Site access hours are anticipated to be between 6 am and 6 pm.

5.2.2 Operational Phase

Noise levels were predicted for the operational phase using distance attenuation calculations to establish predicted noise levels at different distances from the compressor station and pressure regulating facility. Noise levels were also predicted at sensitive receptors for planned maintenance at facilities close to nearby receptors.

The proposed station facilities and their distance to the nearest receptors are detailed in **Table** 5-4.

Table 5-4 Station Facilities

Facility	Location	Distance to closest Noise Receptor km
Main Line Valve (MLV)	Numbulwar Road	>5
	Giddy River Pressure Regulating Facility	>5
	Nhulunbuy	3 to Nhulunbuy Town
	Mainoru	>5
Scraper Stations	Annie Creek	>5
	King River Compressor	>5
	Amadeus tie in	>5
	Gove Refinery	0.98 to Galupa

It is anticipated that only the compressor station at the King River MLV and pressure release regulating facility at the Giddy River scraper station are likely to involve plant items with the potential to emit significant noise levels. The SWLs used in the modeling for these stations is shown in **Table** 5-5. It should be noted that a “typical” noise spectrum obtained from similar facilities and supplier data has been used, as at this stage the final plant and equipment has not been chosen. Therefore it is recommended that they be reviewed once the detailed design is complete.

Table 5-5 Source Sound Power Levels

Source Item	Octave Band Sound Power Level dBL									Total dBA
	31.5	63	125	250	500	1k	2k	4k	8k	
Compressor Station and Pressure Regulating Facility	120	113	110	107	105	104	102	99	94	109

Scraper stations will only emit significant noise during six monthly gas venting, which will occur as part of planned maintenance activities and blow down, which is anticipated to occur approximately every five years.

Planned maintenance events are anticipated to be as follows:

- Six monthly pigging to clean pipeline. The significant noise source from this activity is gas release and the estimated SWL for this is 110 dBA.
- Scraper facility shut down venting. This only occurs on equipment failure or every five years. The estimated SWL for this is 110 dBA.

Both these activities will last thirty seconds in duration and are in accordance with the frequency stipulated in the pipeline licence.

Unplanned depressurising of the pipeline may need to occur if the pipeline or associated ancillary facility is damaged. Venting will occur at both ends of the pipeline to be depressurised at either a scraper station or MLV depending on whether one has been damaged. In the event of a release the SWL is estimated to be 120 dBA and has the potential to last for eight hours.

Unplanned releases are normally emergency events and there are automatic control measures in place for their detection and control. It should be noted that in the case of an emergency, noise is exempt from normal environmental criteria. Therefore unplanned releases are not considered in the assessment.

6 PREDICTION OF NOISE LEVELS

6.1 Construction Noise

The predicted noise levels at the nearest noise sensitive receptors for each stage of construction are shown in **Table** 6-1.

Table 6-1 Predicted Noise Levels Construction Noise

Activity		Predicted L_{Aeq} dB			
		Beswick	**Nhulunbuy**	**Birritjimi**	**Galupa**
Clear and grade		34	43	63	45
Blasting preparation		30	N/A	N/A	N/A
Rock hammering (Gove)		N/A	44	63	45
Trenching, trench breaking, stringing, bending and lowering pipe.		42	51	70	53
Welding and joint coating		32	41	64	48
Hydrotesting, dewatering and drying.	Day Time	32	41	58	43
	Night Time	33	41	58	43
Padding, shading and backfilling.		36	45	64	47
String and pit tie ins and road crossings.		36	41	63	42
Restoration and rehabilitation		36	43	64	47
Commissioning		35	44	62	46

6.2 Operational Noise

Due to the large distances (in excess of 5 km) between the compressor station / pressure regulating facility and the receptors, predicted noise levels have been modelled at different distances surrounding these facilities. These noise levels are shown in **Table** 6-2.

Table 6-2 Predicted Noise Levels Operational Noise Compressor Stations and Pressure Regulating Facility

Distance from Facility km	Predicted L_{A10} dB*
0.5	47
1	41
5	27
10	21

*Including +5 dB correction for tonality.

The predicted noise levels for planned maintenance activities at the potential nearest receptor are shown in **Table** 6-3.

Table 6-3 Predicted Noise Levels Operational Noise

Receptor	Predicted L_{A10} dB[1]		
	Blow Down	Pigging	Scraper Facility Venting
Nhulunbuy	47[2]	>10[3]	>10[3]
Galupa	39[3]	29[3]	29[3]
Birritjimi	34[3]	24[3]	24[3]

[1] Including +5 dB correction for tonality
[2] Nhulunbuy MLV Facility
[3] Gove Refinery Scraper Facility includes barrier effect of refinery structures.

The predicted noise level for the blowdown at Nhulunbuy is greater than the predicted noise levels at Galupa and Birritjimi despite them being closer to their relevant source. This is due to the attenuation afforded by buildings and structures between the Gove Refinery and Galupa and Birritjimi that is not present between the Nhulunbuy MLV and Nhulunbuy Town.

7 ASSESSMENT

7.1 Noise Assessment

7.1.1 Construction Noise

The predicted noise levels at the nearest sensitive receptors compared against the relevant criteria are shown in **Table** 7-1.

Table 7-1 Assessment of Construction Noise

Activity		Beswick		Nhulunbuy		Birritjimi		Galupa	
		Specific Criteria L_{Aeq} dB	**Predicted L_{Aeq} dB**	**Specific Criteria L_{Aeq} dB**	**Predicted L_{Aeq} dB**	**Specific Criteria L_{Aeq} dB**	**Predicted L_{Aeq} dB**	**Specific Criteria L_{Aeq} dB**	**Predicted L_{Aeq} dB**
Clear and Grade		54	34	67	43	65	63	67	45
Blasting Preparation		54	30	N/A	N/A	N/A	N/A	N/A	N/A
Rock Hammer		N/A	N/A	67	54[1]	65	**73**[1]	67	55[1]
Trenching, trench breaking, stringing, bending and lowering pipe.		54	42	67	51	65	**70**	67	53
Welding and Joint Coating		54	32	67	41	65	64	67	48
Hydrotesting, dewatering and drying	Day Time	54	32	67	41	65	58	67	43
	Night Time	35[2]	33	35[2]	**41**	35[2]	**58**	41[2]	**43**
Padding, shading and backfilling		54	36	67	45	65	64	67	47
String and pit tie ins and road crossings		54	36	67	41	65	63	67	42
Restoration and rehabilitation		54	36	67	43	65	64	67	47
Commissioning		54	35	67	44	65	62	67	46

[1]+10 dB Correction applied for impulsiveness.
[2]No night time criteria in the NT EPA construction guidelines, WA noise Regulations night time criteria referenced.

The predicted noise levels at the receptors at Beswick, Nhulunbuy and Galupa for all construction activities are compliant with the day time criteria contained within the NT EPA construction guidelines.

The predicted noise levels at the receptors within Birritjimi due to their proximity to the proposed pipeline route exceed the criteria contained within the NT EPA construction guidelines for the following scenarios:

- Rock hammer.
- Trenching, trench breaking, stringing, bending and lowering the pipe.

All the remaining day time scenarios at Birritjimi are within the criteria contained within the NT EPA construction guidelines.

It should be noted that the only activity scheduled to take place during the night time period is the hydrotesting. The noise levels from this activity exceed the criteria contained within the noise Regulations at Nhulunbuy, Birritjimi and Galupa. Hydrotesting takes place over a twenty four hour period and the noise generating plant is located at the fill end of the pipeline, at least 50 km of pipe can be tested per section. It is therefore possible to locate the fill end away from the sensitive receptors at Nhulunbuy, Birritjimi and Galupa to mitigate the noise impact.

Construction Traffic Noise

Katherine due to its higher existing traffic count and lower predicted increase in traffic from construction activities should not experience any notable increase in noise levels.

Due to the rural nature of the proposed pipeline route and low traffic volumes on the surrounding roads, peak construction traffic will significantly increase existing traffic volumes at Barunga and Nhulunbuy.

If the diurnal daily peak construction traffic occurs around 6.00 am and 6.00 pm, traffic noise is not expected to cause any adverse impacts on nearby communities. However, adverse driver behaviour, particularly along routes close to residences and at any stage during the night time period, could potentially cause annoyance to local residents.

7.1.2 Operational Noise

The predicted noise levels at the nearest sensitive receptors to the compressor station / pressure regulating facility would be below L_{A10} 27 dB as no sensitive receptors could be found within a 5 km radius of these operations. This noise level (including the correction of plus 5 dB for tonality) is compliant with the criteria for all periods contained within the noise Regulations.

The predicted noise levels from planned maintenance activities at the nearest noise sensitive receptor compared against the specific criteria are shown in **Table** 7-2.

Table 7-2 Assessment of Planned Maintenance

Receptor	Specific Criteria L_{A10} dB		Predicted L_{A10} dB[1]		
			Blow Down	Pigging	Scraper Facility Venting
Nhulunbuy	Day	45	**47**[2]	>10[3]	>10[3]
	Evening	40			
	Night	35			
Galupa	Day	51	39[3]	29[3]	29[3]
	Evening	46			
	Night	41			
Birritjimi	Day	45	34[3]	24[3]	24[3]
	Evening	40			
	Night	35			

[1] Including +5 dB correction for tonality
[2] Nhulunbuy MLV Facility
[3] Gove Refinery Scraper Facility

The predicted noise levels at the receptors exceed the noise Regulations in the following instances:

- The blowdown exceeds the day time criteria, evening criteria and the night criteria at Nhulunbuy.

Blow downs are likely to occur once every five years for eight hours. Compliance with the criteria for the blow downs is dependent on whether they are part of a planned release or whether it is an emergency situation. As discussed earlier within **Section 5.2.2** the emergency situation would not have to meet the noise criteria.

7.2 Vibration (Blasting) Assessment

The exact locations of the blasting or more accurately referred to as “shallow depth rock fracturing” are not known. Areas of likely requirement have been nominated but the requirement for such will be defined by bore drilling surveys to better ascertain the extent if any of the route requiring this process. It is proposed to undertake these operations where rock is found that cannot be otherwise excavated (by chain trencher) within the trench depth required.

Based on the limited existing information available it is not anticipated that blasting will be undertaken in the vicinity of the receptors at Gove and it is noted that there is a possibility of blasting being required within the Mitchell Ranges, however this will be confirmed during drilling surveys. As no sensitive receptors could be identified within at least 5 km of the proposed pipeline route within the Mitchell Ranges vibration and air blast levels are not anticipated to cause any structural damage or nuisance. However, as blasting locations become identified through field testing, more in depth assessments will be required where potential sensitive receptors are identified.

As the exact locations of blasting / shallow depth rock fracturing have not yet been determined, a conservative blasting assessment has been undertaken with reference to the nearest sensitive residential receptor along the proposed KGGP alignment. As the ground vibration and airblast emissions decrease with distance from a potential blast site, an assessment of blast emissions at the closest receptor would indicate the maximum likely blast emissions levels at any residence.

The blasting assessment was therefore conducted with reference to the nearest receptor to the route not within the Gove Peninsula, being the closest residence in Beswick, located approximately 1.5 km from the proposed route. It should be noted that it has not been determined if blasting will actually be required at Beswick as this will be determined from the findings of the drilling surveys. Accordingly, the predicted blast emissions indicate the maximum likely blast emissions levels at any residence.

The predicted emission levels are based on the highest Maximum Instantaneous Charge (MIC) that can be used without resulting in any exceedances and for comparison, 75% of that value. It is anticipated that the actual charge mass used during the pipeline construction will be significantly below the MIC.

Table 7-3 Predicted Overburden Blast Emissions

Assessment Location	Distance to Blast km	Peak Vector Sum (PVS) Vibration mm/s			Peak Linear Airblast dB re 20µPa		
		Criteria	MIC 178 kg	75%MIC 134 kg	Criteria	MIC 178 kg	75% MIC 134 kg
Beswick	1.5	5	1	0.8	115	115	114

Note: This assessment assumes the actual blast parameters would be designed to ensure the ANZEC guidelines are met at all receptors.

A review of the blast emission levels presented in **Table** 7-3 indicates that, for an MIC of 178 kg, the blast emissions at all receptors are predicted to comply with the *Environmental Protection (Noise) Regulations 1997* recommended airblast limit (i.e. 115 dB) and the ANZEC guidelines for ground vibration (i.e. 5 mm/s) at the nearest receptors.

The following information is also derived from the predicted levels of blast emissions:

- The predicted levels of ground vibration for a permissible MIC of 178 kg at all nearby receptors comply with the ANZEC general human comfort criterion (of 5 mm/s) and consequently with the ANZEC maximum human comfort criterion, as well as the BS 7385 structural damage criterion of 15 mm/s (at 4 Hz) under the indicative MIC range at all residences within Beswick.
- The predicted levels of peak airblast at all receptors comply with the *Environmental Protection (Noise) Regulations 1997* airblast criterion of 115 dB Linear for the indicative MIC range at all residences within Beswick.
- The predicted levels of peak airblast are below the US Bureau of Mines damage limit of 132 dB Linear (2 Hz cut off) at all non-mine receptors.

8 CONCLUSION AND RECOMMENDATIONS

8.1 Construction Noise

The construction noise assessment was undertaken using certain scenarios containing likely plant numbers of construction equipment operating simultaneously. Following this assessment it can be concluded that the potential for noise impacts at the nearest receptors within Beswick, Nhulunbuy and Galupa is low during day time construction of the proposed pipeline, as all the predicted levels are in compliance with the NT EPA construction guidelines. The predicted noise levels at Birritjimi due to its close proximity to the proposed pipeline route exceed the criteria during the following scenarios:

- Rock hammer.
- Trenching, trench breaking, stringing, bending and lowering the pipe.

In order to reduce the impact from construction noise at Birritjimi from these activities, it is recommended to consider the following in principle noise controls:

- When rock hammering use localised acoustic shrouds around the plant.
- Fit noisy plant with engine and muffler kits.
- Erect a temporary barrier along the southern side of Birritjimi.
- Limit the numbers of plant operating simultaneously in particular the number of semi-trailers during the trenching activities.
- Locate fixed plant items as far from Birritjimi as practical and place them behind temporary acoustic barriers.
- No noisy work operations should be undertaken during the night time period whenever possible.

Hydrotesting at night was identified to potentially exceed the acceptable criteria at night time in the vicinity of Nhulunbuy, Birritjimi and Galupa. However, the plant associated with this activity can be placed at fill points along the pipeline to ensure that they do not have an impact on these receptors. It is therefore recommended that fill points for hydrotesting are located at least 2 km from a nearby receptor so as not to cause a night time noise impact.

Adherence to the noise criteria will be ensured through the development of a noise management plan. The noise management plan will cover the mitigation strategies for activities close to Birritjimi and night time construction activities (hydrotesting) due to the potential for noise impact at Nhulunbuy, Galupa and Birritjimi. The noise management plan will also detail complaint management procedure and community consultation strategies.

The duration of construction activities for the pipeline would be relatively short and even shorter in any one location, and impacts on wildlife from construction noise are expected to negligible. Notwithstanding, it is recommended that construction activities avoid, as far as practicable, sudden loud or impulsive or impact noises in the vicinity of known significant active wildlife breeding areas. If possible, works should be scheduled near the main roosting areas to avoid breeding season.

Construction Traffic Noise

Due to limited information and low current traffic volumes on potential access routes a qualitative assessment was carried out. Based on this assessment it is anticipated that along as peak construction traffic volumes occur around 6.00 am and 6.00 pm adverse impacts on surrounding communities is unlikely.

Construction traffic noise should be included in the noise management plan and address:

- Adverse driver behaviour.
- Limiting non-essential construction traffic to the daytime period.
- Consideration of heavy vehicle transportation times.
- Notification to residents within 500 m of a construction traffic route prior to construction.

8.2 Operational Noise

Due to the large separation distance between the compressor station / pressure regulating facility and the nearest receptors, the predicted noise levels based on the estimated sound power levels of the facilities and their operations, are within the criteria contained within the noise Regulations.

Planned maintenance was also assessed and exceedances of the noise Regulations were identified at Nhulunbuy. As it is not a continuous noise source any associated noise emissions will occur very infrequently. However, due to the high noise levels associated with venting events, it is recommended that vent locations are situated as far away as practicable from sensitive receptors. Applying a silencer to the vents at Nhulunbuy MLV should also be considered.

Furthermore it is recommended that where sensitive receptors are located within 5 km of a vent that they are notified at least 48 hours prior to an event and a noise management plan be created. Planned maintenance when possible should be scheduled for the day time period.

8.3 Vibration (Blasting)

Based on the results of the blast emission assessment the predicted vibration and airblast levels based on the MIC will be within the relevant criteria and therefore the vibration impact of the proposed project on the nearby sensitive receptors is predicted to be low.

Adherence to the nominated criteria will be managed by restricting the charge mass used for each to within the MIC.

9 REFERENCES

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Appendix A - Acoustic Terminology

1 Sound Level or Noise Level

The terms "sound" and "noise" are almost interchangeable, except that in common usage "noise" is often used to refer to unwanted sound.

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

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

2 "A" Weighted Sound Pressure Level

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

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

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

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

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

3 Sound Power Level

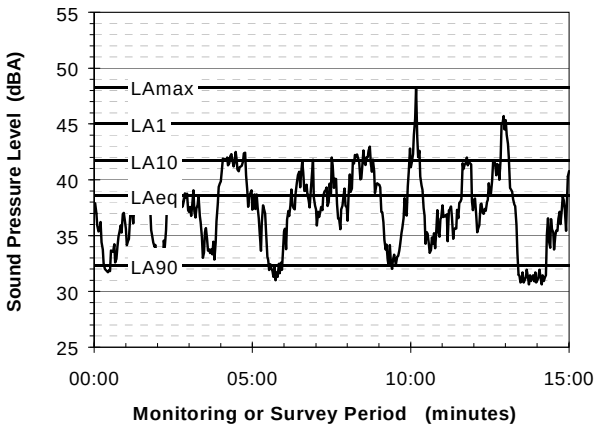
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the "repeatable minimum" L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or "average" levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc.).

5 Tonality

Tonal noise contains one or more prominent tones (i.e. distinct frequency components), and is normally regarded as more offensive than "broad band" noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

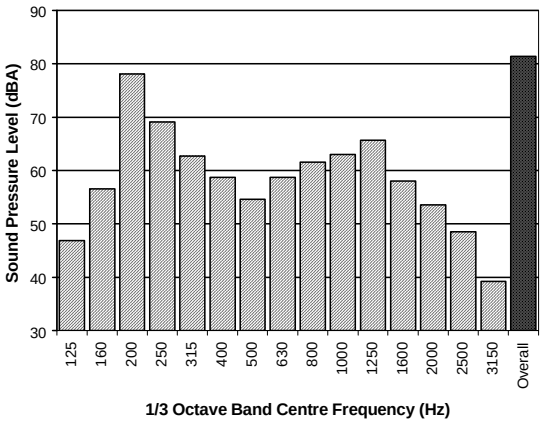
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

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

9 Human Perception of Vibration

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

10 Over-Pressure

The term “over-pressure” is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (i.e. unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

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

The term “regenerated noise” is also used in other instances where energy is converted to noise away from the primary source.

Appendix B – Pipeline Route and Infrastructure