Queensland Hunter
Gas Pipeline

Appendix G
Noise and vibration assessment

HEGGIES

REPORT 10-5693-R2

Revision 3

Queensland - Hunter Gas Pipeline

Construction Noise and Vibration Assessment

PREPARED FOR

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Queensland - Hunter Gas Pipeline

Construction Noise and Vibration Assessment

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been commissioned by Manidis Roberts to assess the potential for noise and vibration impacts during construction of the proposed Queensland Hunter Gas Pipeline (QHGP). This study provides a qualitative assessment of potential noise and vibration impacts and is for the environmental assessment.

The QHGP will run from Wallumbilla in south central Queensland to the Newcastle area in NSW, travelling a total of 825 km in length.

The pipeline will comprise a single high pressure pipeline constructed from high strength steel with a nominal diameter of 500 mm and buried to a minimum depth of 750 mm (depending on land use). The right of way during construction will be 30 m in width. Additional working room (up to 50 m) may be required for river and infrastructure crossings and the impact width may be reduced at environmentally sensitive locations.

The study area for this assessment includes the pipeline route corridor within NSW only, from the Queensland/NSW border to the Newcastle area.

Acoustic terminology used in this report is presented in **Appendix A**.

2 DESCRIPTION OF THE PROPOSAL

Construction of the pipeline will require a number of operations to be undertaken consecutively as follows:

1. Survey and fencing;
2. Set up of temporary facilities;
3. Clear and grade of the right of way;
4. Trenching;
5. Pipe stringing and bending;
6. Pipe welding, inspection;
7. Joint coating;
8. Pipe placement (lowering and laying)
9. Backfilling and compaction
10. Hydro-testing and rehabilitation

The suite of activities shown is referred to as a spread. It is currently planned that two pipeline construction spreads will be operating simultaneously over the total length of the pipeline.

One spread will construct the northern portion of the pipeline, including the Queensland section, and another will construct the more populous southern length of the pipeline in NSW. Additional small teams will be required for areas involving specialised construction techniques, including horizontal bore drilling and above ground facility installation.

For conventional pipeline laying (land clearing, trench digging and pipe placement) each crew works at the rate of about 3 km to 4 km per day depending on the terrain (ie if there are more trees or the ground is very rocky progress may be slower). To enable the crews to work safely and efficiently there is often a delay between the arrival dates of each crew. Typically it will take up to 12 weeks for all the crews to pass through an area and complete their tasks.

Blasting is also required in areas of rock, including the Liverpool ranges and the northern Hunter Valley region.

Aspects of the construction program which have the potential to impact on nearby residences are summarised in **Table 1**.

Table 1 Construction Characteristics

Construction Element	Details
Width of vegetation clearing	30 m
Depth of Trench to provide the minimum depth of cover required under *AS 2885*	Generally 1250 mm Deep Cultivated Areas 1700–2500 mm Road Crossings - 1700 mm River Crossings 2500 mm
Construction Hours	7.00 am - 6.00 pm / 7 Days a Week (unless otherwise stated)
Construction Duration	8 months
Refuelling	Mobile fuel truck and construction depot
Time between clear and grade and reinstatement	Up to 4 Months[1]

Note 1: Whilst the time from commencement of works to completion at any site along the route is expected to be up to 4 months, during this period intensive activities such as land clearing and trench construction will occur for less than one month.

For the majority of its length, the pipeline will be located distant from populated centres and rural residences. However, it passes adjacent to a number of towns along the route and, dependant on the separation distance, may cause impacts during the construction and operational phases of the project. The pipeline passes adjacent to the rural towns of Moree, Narrabri, Boggabri, Gunnedah, Werris Creek, Quirindi, Murrurundi, Scone, Aberdeen and Muswellbrook. As the route approaches Newcastle, the adjacent areas are generally more densely populated thereby increasing the likelihood of sensitive receivers being sufficiently close to the route to experience potential noise and vibration impacts.

Potential construction impacts on populated centres and isolated residences will be a function of the distance to the construction works.

It is proposed that construction would occur from 7.00 am to 6.00 pm, seven days per week (unless otherwise stated). Sensitive receivers within close proximity to the pipeline easement would be temporarily affected during periods of activity that would occur from time to time throughout the construction phase. This is due primarily to the transient nature of pipeline construction, whereby construction teams completing specific activities move along the route, completing one aspect of construction (for example clearing vegetation), prior to another team subsequently coming through and performing another activity (for example the removal of topsoil and excavation). The pipeline is proposed to be located in a trench of the order of 1250 mm in depth, excavated using conventional techniques. Typically, this will involve bulk excavating machinery such as bulldozers ripping and excavators and chain or wheel trenchers. Blasting of rock is also proposed through a section of the Liverpool Ranges and in some areas on the northern edge of the Hunter Valley region where the rock is not rippable. Hard rock is present for approximately 45 km of the pipeline route. Blasting is anticipated through these areas in the Liverpool Ranges and in some areas along the northern edge of the Hunter Valley region.

The potential impacts from noise and vibration that may result from the proposal during construction include:

- Noise and vibration created by study teams, such as geotechnical surveys, vehicles and aircraft.

- Noise and vibration created by construction teams and associated machinery, including camps, affecting sensitive receivers during the construction period.

3 NOISE AND VIBRATION GUIDELINES AND CRITERIA

3.1 Construction Noise Criteria

The Department of Environment and Climate Change (DECC) has published guidelines in its Environmental Noise Control Manual (ENCM, Chapter 171 1) for the control of construction noise.

In summary, the DECC's preferred approach to the control of construction noise involves the following:

- Level restrictions.
- Time restrictions.
- Silencing.

a. Level Restrictions

For a cumulative period of exposure to noise from construction activity of up to 4 weeks in duration, the $L_{A10(15minute)}$ noise level emitted by the works, when measured at a residential receiver, should not exceed the $L_{A90(15minute)}$ RBL (background noise level) by more than 20 dBA.

For a cumulative period of exposure to noise from construction activity of between 4 weeks and 26 weeks duration, the $L_{A10(15minute)}$ noise level emitted by the works, when measured at a residential receiver, should not exceed the $L_{A90(15minute)}$ RBL more than 10 dBA.

For a cumulative period of exposure to noise from construction activity in excess of 26 weeks duration, the $L_{A10(15minute)}$ noise level emitted by the works, when measured at a residential receiver, should not exceed the $L_{A90(15minute)}$ RBL by more than 5 dBA.

b. Time Restrictions

Monday to Friday	7.00 am to 6.00 pm.
Saturday	7.00 am to 1.00 pm if inaudible at residential premises; otherwise, 8.00 am to 1.00 pm.

No work on Sundays or Public Holidays.

Should any construction works be undertaken outside these hours, a separate assessment of their impacts will be carried out once the nature and extent of those works is known.

c. Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required.

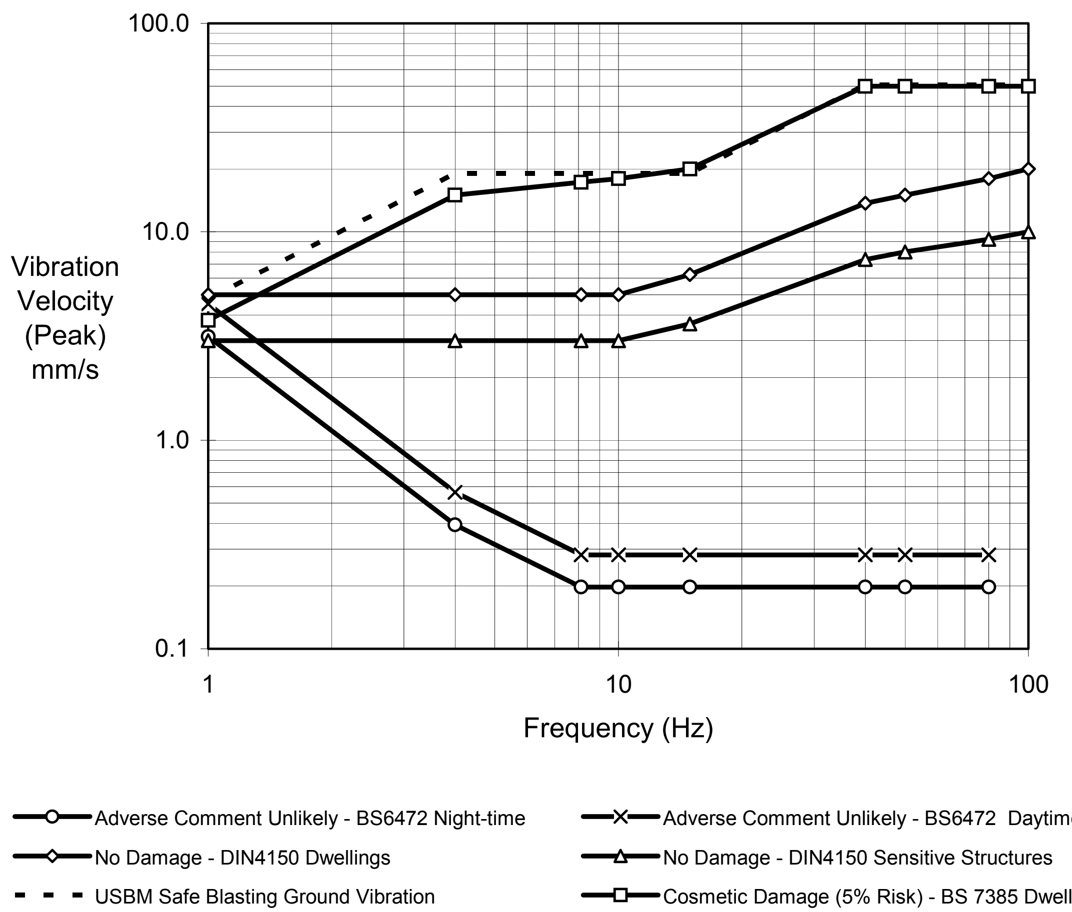
3.2 Construction Vibration Control Guidelines

When dealing with construction vibration, the effects in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed;
- Those in which the integrity of the building or the structure itself may be prejudiced; and
- Those where the building contents may be affected.

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. **Figure 1** illustrates this difference in susceptibility by comparing widely accepted human disturbance criteria (BS 6472) with various threshold damage levels (DIN 4150, US Bureau of Mines and BS 7385).

Figure 1 Human Disturbance Criteria and Building Damage Limits.



Notes: BS 6472 "Adverse Comment" disturbance criteria are for continuous vertical vibration at point of entry to body. DIN 4150 "No Damage" threshold criteria are peak particle velocity on building footings. BS 7385 5% Risk of Cosmetic Damage criteria are peak particle velocity on building footings (or in ground nearby). US Bureau of Mines Safe Blasting criteria are peak particle velocity in the ground

3.3 *Assessing Vibration: a technical guideline*

The DECC's "*Assessing Vibration: a technical guideline*" is based on the guidelines contained in British Standard BS 6472-1992. BS 6472 refers only to the human comfort criteria for vibration.

For daytime activities, the limiting objective for continuous vibration (eg continuous construction or maintenance activity) at residential receivers is V_{rms} 0.4 mm/s, and for commercial receivers 0.8 mm/s. Furthermore DECC's *technical guideline* sets a daytime limiting objective for impulsive vibration (eg the occasional loading and unloading, or dropping of heavy equipment) of V_{rms} 12 mm/s for residences, and 26 mm/s for commercial receivers.

BS 6472 also contains a formula for the Vibration Dose Value (VDV), which can be used to evaluate intermittent vibration or vibration levels that vary significantly over time. As the vibration becomes continuous, this VDV trends to the continuous vibration criterion.

3.4 Effects of Vibration on Structures

It is generally recognised that damage criteria should not be specified in terms of vibration velocity alone, but should be further defined with an associated frequency or frequency range to account for the possible resonance effects within structures and the lower susceptibility to damage of structures to higher frequencies of vibration. Vibration amplification can occur within a structure if the frequencies of significant levels of ground vibration energy are close to or coincide with the natural (resonant) frequencies of the structural components. While structures can have many modes of vibration, the natural frequencies of major building elements are usually well below 40 Hz.

- Most single-storey structures have a superstructure or "whole body" natural frequency in the order of 5 Hz. The pattern of this vibration is often referred to as "racking", where the floors and ceilings vibrate horizontally in opposite directions.
- Walls and floors have fundamental frequencies generally between 8 Hz and 25 Hz. These modes of vibration represent panel modes or diaphragm action, somewhat like a vibrating drum skin. They are the modes of vibration most easily excited by thunder and other low frequency noise sources such as diesel engines and empty truck bodies.

Suspected damage to structures caused by ground vibration from construction works often involves other contributing factors. These include poor foundation conditions, differential foundation settlement, reactive soils and changing weather patterns, differential thermal expansion, inadequate structural design, deficient construction methods and structural overloading. Generally, no single factor is usually solely responsible for the onset of damage and all can be exacerbated by the presence of vibration.

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels having the potential to cause damage to the main structure. It would only be in extreme or unusual situations that these "safe" vibration limits would not adequately cater for the existing stress condition of the structure.

3.4.1 German Standard DIN 4150-3:1999 Guidelines

German Standard DIN 4150-3: 1999 "*Structural vibration Part 3: Effects of vibration on structures*" provides guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

As opposed to the *"minimal risk of cosmetic damage"* approach adopted in BS 7385, the *"safe limits"* given in DIN 4150 are the vibration levels up to which no damage due to vibration effects has been observed. Hence, the guideline limits in DIN 4150 are somewhat lower than those in BS 7385.

The DIN 4150 values (maximum levels measured in any direction at the foundation, OR, maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), for the evaluation of short-term building vibration are summarised in **Table 2**.

The minimum "safe limit" of peak vibration velocity at low frequencies for commercial buildings (as per the subject building) and buildings of similar design is 20 mm/s (Line 1). For dwellings and buildings of similar design and/or use it is 5 mm/s (Line 2) and for structures which may be particularly sensitive to ground vibration, such as historic buildings with preservation orders (Line 3), it is 3 mm/s.

It should be noted from **Table 2** that levels higher than these minimum figures for low frequencies may be quite "safe", depending on the frequency content of the vibration.

It should also be noted that these levels are "safe limits", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Table 2 DIN 4150 - Structural Damage - Safe Limits for Short-Term Building Vibration

Line	Type of Structure	Guideline Values for Vibration Velocity in mm/s			
		Vibration at the Foundation at a Frequency of			Vibration at Horizontal Plane of Highest Floor at All Frequencies
		1Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings under preservation order)	3	3 to 8	8 to 10	8

Source - German Standard DIN 4150-3: 1999

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

When damage is observed without vibration levels exceeding the "safe limits", DIN 4150 suggests that it may be attributed to other causes. Finally, DIN 4150 states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

All of the above qualifications found in DIN 4150 are testament to the degree of uncertainty that exists between vibration and damage.

It can be clearly seen that the levels of tactile human perception to vibration (as discussed in **Section 3.2**) are well below the "damage" levels specified by Group 3 in DIN 4150 for the most sensitive of structures. This comparison assists in giving an understanding of the relationship between human response to vibration and perceived potential for damage. People are typically able to detect vibration at levels much lower than those required to cause even superficial damage to the most susceptible class of building.

3.4.2 Guidelines from BS 7385

In terms of relevant vibration damage criteria, BS 7385: Part 2-1993 is often viewed as a definitive standard against which the likelihood of building damage from ground vibration can be assessed.

In general, there is a lack of reliable data on the threshold of vibration-induced damage in buildings in countries where national standards already exist. BS 7385: Part 2 was developed from an extensive review of UK data, relevant national and international documents and other published data. 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 (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The strain imposed on a building at foundation level is proportional to the peak particle velocity but is inversely proportional to the propagation velocity of the shear or compressional waves in the ground. Hence, the peak particle velocity has been found to be the best single descriptor for correlating case history data with the occurrence of vibration-induced damage.

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** and graphically in **Figure 2**.

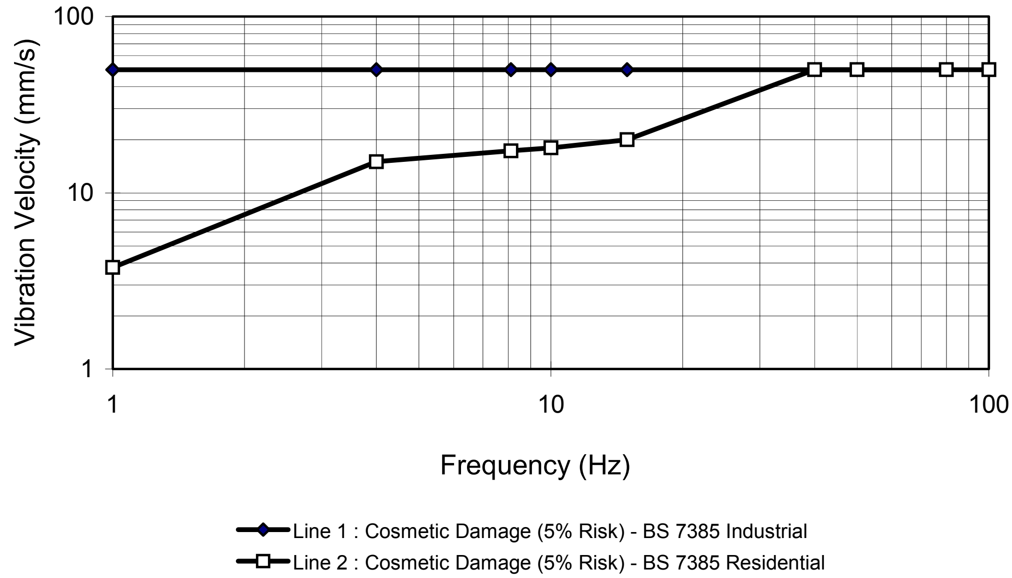
Table 3 Transient Vibration Guide Values for Cosmetic Damage

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

The BS 7385 guide values for building types corresponding to Line 2 are a function of frequency. In particular, the lower the frequency, the more stringent the guide values (as is the case for DIN 4150).

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 3.3.1, and major damage to a building structure may occur at values greater than four times the tabulated values.

Figure 2 Human Disturbance Criteria and Building Damage Limits.



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 2** should not be reduced from fatigue considerations.

Finally, BS 7385 states that the guide values in **Table 2** relate predominantly to transient vibration where resonant response of the structure or structural elements is not an issue. Where dynamic magnification is suspected, BS 7385 suggests that the guide values may need to be reduced by up to 50%.

3.5 Project Specific Construction Noise and Vibration Criteria

Project specific construction noise criteria have been set that correspond to major, moderate and minor impacts, with reference to the DECC guidelines presented in **Section 3.1**, and recognising intensive activities will generally occur for less than one month.

Table 4 Construction Noise Criteria - $L_{A10(15minute)}$ Noise Levels

Construction Noise	Major (Background +20 dBA)	Moderate (Background +10 dBA)	Minor (Background +5 dBA)
Isolated Residence	50 dBA	40 dBA	35 dBA
Township Residences	55 dBA	45 dBA	40 dBA

Note 1: Assumed L_{A90} or Rated Background Levels for Isolated rural residences are 30 dBA, and 35 dBA for residences in rural and semi rural towns.

Project specific vibration criteria have been set that correspond to major, moderate and minor impacts, with reference to the standards presented in **Sections 3.2, 3.3** and **3.4**. The criteria are presented in **Table 5**, noting the values are based on guidelines for cosmetic building damage and human comfort.

Table 5 Construction Vibration Criteria

Construction Vibration	Major	Moderate	Minor [2]
All Residences [1]	10 mm/s	5 mm/s	1.6 mm/s

Note 1: Peak Component Vibration Velocity.

Note 2: The 1.6 mm/s minor criterion is based on a Vrms vibration velocity of 0.4 mm/s and a crest factor of 4 (ie $C = x_{peak}/x_{rms}$)

3.6 Blasting Emissions Criteria

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 criteria normally recommended for blasting in NSW, based on human discomfort, are contained in the DECC's ENCM (Chapter 154). However, for recent projects the DECC has advocated the use of the Australian and New Zealand Environment Council (ANZEC) guidelines.

The ANZEC criteria for the control of blasting impact at residences are as follows:

- The recommended maximum level for airblast is 115 dB Linear.
- The level of 115 dB Linear may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level should not exceed 120 dB Linear at any time.

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

- 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.
- Blasting should generally only be permitted during the hours of 9.00am to 5.00 pm Monday to Saturday. Blasting should not take place on Sundays and public holidays

3.7 Project Specific Blasting Criteria

Project specific blasting noise and vibration criteria have been set that correspond to moderate and minor impacts, with reference to the DECC guidelines presented in **Section 3.6**. These criteria are presented in **Table 6**.

Table 6 Blast Vibration and Airblast Criteria

Airblast	Moderate	Minor
All Residences	120 dBL	115 dBL
Blast Vibration	**Moderate**	**Minor**
All Residences [1]	10 mm/s	5 mm/s

Note 1: Peak Component Vibration Velocity.

4 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

4.1 Construction Overview

Construction activities have been separated into construction of the pipeline trench, placement of the pipe and horizontal bore drilling sections.

4.2 Trench Construction

Table 7 Description of Trench Construction Works

Construction Phase	Construction Activity	Description of Equipment
Preparation of Right of Way	Survey and fencing	Crew vehicles, trucks, tractors
	Land clearing	Bulldozers, graders, backhoes
Trench construction	Digging of trench	Chain trencher/wheel trencher, excavator
Miscellaneous works	Provision of power and light	Daymakers (lights), pumps, generators

4.3 Pipe Placement and Rehabilitation

Table 8 Description of Pipe Placement and Rehabilitation Works

Construction Phase	Construction Activity	Description of Equipment
Pipe unloading	Pipe unloading and preparation	Trucks, sideboom tractors
Pipe preparation	Welding, grit blasting pipe placement	Grit blasting, generator, compressor
Pipelaying and rehabilitation		Sideboom tractors, excavator, graders roller
Miscellaneous works	Provision of power and light	Daymakers (lights), pumps, generators

4.4 Horizontal Bore Drilling

Table 9 Description of Horizontal Bore Drilling

Construction Phase	Construction Activity	Description of Equipment
Launch and receival shaft	Dig and prepare tunnel shaft for boring Machine	Excavator, crane, generator
Tunnel Boring	Bore hole and push piping through	Tunnel boring machine, crane, generator, compressor
Place, fix and install pipeline		Crane, truck, generator
Miscellaneous Works	Provision of power and light	Daymakers (lights), pumps, generators

4.5 Equipment Sound Power Levels

The sound power levels given in **Table 10** are maximum noise emission levels of plant that would be used on this project during typical operations. In order to apply the construction noise criteria for the project, it is necessary to convert these levels to equivalent $L_{A10(15minute)}$ noise emissions. From numerous field studies on large construction projects, the measured difference values between the L_{Amax} and the $L_{A10(15minute)}$ noise level have been found to be up to 10 dBA, depending on the mixture of the plant, intensity of operation and location of the plant relative to the receiver.

Table 10 Summary of Sound Power Levels used for Construction Equipment (Prior to Mitigation)

Plant Item	L_{Amax} Sound Power Level (re 1 pW)
D8 Bulldozer	118 dBA
Grader	110 dBA
Backhoe	108 dBA
Excavator (30 tonne)	110 dBA
Sideboom tractor	110 dBA
Concrete truck	112 dBA
Roller (non vibratory)	110 dBA
Vibratory Roller	114 dBA
Dump truck (approx 15 tonne)	108 dBA
Chain trencher	118 dBA
Wheel trencher	118 dBA
Tunnel boring machine	111 dBA
Generator	104 dBA
Compressor (approx 600 CFM)	105 dBA
Daylight	90 dBA
Pump	100 dBA
Hand Tools	98 dBA
Reversing Alarm	110 dBA

In the present study, where the receivers are relatively distant, the following adjustments have been applied to convert the L_{Amax} noise levels shown in **Table 10** to $L_{A10(15minute)}$ noise levels for comparison with the construction noise design objectives:

- 2 dBA for equipment characterised by reasonably continuous noise emissions (eg compressors, chain and wheel trenchers, concrete unloading, etc).
- 5 dBA for dozers, excavators, sideboom tractors and dump trucks.

4.6 Noise Assessment at Potentially Affected Residences

In order to assess the noise impacts of the various pipeline construction activities, noise emission calculations were carried out to determine sideline distances at which compliance of the major, moderate and minor design criteria presented in **Table 4** are achieved. The calculations assume propagation over flat, soft ground (ie open grassland) to a typical receiver. Note, as the construction noise is anticipated to be of a relatively short distance, the noise level calculations do not include any meteorological enhancement, for example due to a slight breeze towards the receiver, or due to a temperature inversion.

Table 11 Offset Distances to Comply with Design Criteria - Isolated Residences

Construction Phase	Main Construction Activities	Offset Distance to Residence		
		Major Impact 50 dBA Criterion	Moderate Impact 40 dBA Criterion	Minor Impact 35 dBA Criterion
Preparation of Right of Way	Bulldozers, graders, backhoes	280 m	525 m	680 m

Construction Phase	Main Construction Activities	Offset Distance to Residence		
		Major Impact 50 dBA Criterion	Moderate Impact 40 dBA Criterion	Minor Impact 35 dBA Criterion
Trench construction	Chain trencher/wheel trencher, excavator	350 m	600 m	750 m
Pipe preparation	Grit blasting	220 m	420 m	560 m
Pipe unloading, laying and rehabilitation	Sideboom tractors, graders, rollers	200 m	400 m	520 m
Horizontal bore drilling	Tunnel boring machine, excavator	220 m	420 m	560 m
Miscellaneous Works	Daymakers, pumps, generators	120 m	260 m	370 m

Note 1: The distance is calculated based on the expected summation of noise sources at the receiver for the noisiest activity. Depending on the scenario the level may result from the noisiest operation, or be from multiple sources. Note as L_{A10} noise levels are statistical they cannot be simply summed based on acoustical energy at the receiver.

Table 12 Offset Distances to Comply with Design Criteria - Township Residences

Construction Phase	Main Construction Activities	Offset Distance to Residence		
		Major Impact 55 dBA Criterion	Moderate Impact 45 dBA Criterion	Minor Impact 40 dBA Criterion
Preparation of Right of Way	Bulldozers, graders, backhoes	200 m	400 m	525 m
Trench construction	Chain trencher/wheel trencher, excavator	250 m	480 m	600 m
Pipe preparation	Grit blasting	140 m	300 m	420 m
Pipe unloading, laying and rehabilitation	Sideboom tractors, graders, rollers	200 m	280 m	400 m
Horizontal bore drilling	Tunnel boring machine, excavator	140 m	300 m	420 m
Miscellaneous Works	Daymakers, pumps, generators	75 m	180 m	260 m

Note 1: The distance is calculated based on the expected summation of noise sources at the receiver for the noisiest activity. Depending on the scenario the level may result from the noisiest operation, or be from multiple sources. Note as L_{A10} noise levels are statistical they cannot be simply summed based on acoustical energy at the receiver.

4.6.1 Receiver Identification and Qualitative Noise Assessment

Sensitive receivers (eg isolated residences, residential zones, residential zones or towns) were identified based on a desktop Geographic Information Systems (GIS) analysis. The currently available aerial resolution varied over the pipeline route and where adequate (eg near Scone and Kooragang Island), likely residential areas and residences have been identified. It is anticipated that as the aerial resolution of the route is further developed during the design phase, additional residences will be identified.

Towns, residential areas, and isolated receivers identified that are typically within 1km of the pipeline are listed in **Appendix B**. **Appendix B** lists the distance to towns and residential areas where the town or residential area could be referenced by the desktop GIS analysis. For isolated residences, **Appendix B** references the location to the pipeline kilometre post (KP) distance as shown on the QHGP route dated 15 January 2008 and provided by Geoscience Australia.

With reference to the offset distances provided in **Table 11** and **Table 12**, the noisiest activity is "trenching", and the corresponding offset distances are 750 m, 600 m and 350 m for minor, moderate and major impacts for isolated receivers, and 600 m, 480 m and 250 m for minor, moderate and major impacts for township receivers. Based on the offset distances identified and presented in Appendix B the following is concluded:

- Minor impacts are expected at the towns of Tomago and Tinowon, moderate impacts at Fredona and Beechwood, and major impacts at Ardglen and Borambil.
- Moderate to major impacts are expected at most of the 18 isolated residences/residential areas identified (noting the area of adequate resolution to identify receivers is only for approximately 100 km of the 820 km route). It would be anticipated that as the aerial resolution of the route is developed, there will be a corresponding increase in the number of residences identified during detailed design.

4.7 Construction Vibration

The major potential source of construction vibration includes bulldozers ripping rock strata.

Bulldozers

Typical ground vibration levels from bulldozers range from 1 mm/s to 2 mm/s at a distance of approximately 5 m. At distances greater than 20 m, vibration levels are usually below 0.2 mm/s.

Expected Vibration Impacts

In general, vibration produced by earthworks is expected to lie below the minor structural damage criteria. A review of vibration impacts is recommended after all potentially affected residences along the route are identified and offset distances determined.

4.8 Noise Mitigation of Construction Activities

Given the number and degree of potential exceedances indicated, comprehensive noise mitigation strategies should be implemented wherever possible during the construction works. These strategies can be applied to both the "moving" trench construction worksite and the "fixed" trenchless construction sites.

4.8.1 Noise Mitigation Strategies

AS 2436-1981 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites*" sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the project are listed below, including the typical noise reduction achieved, where applicable.

Construction Strategies

- Construction hours of the works will be nominally 7.00 am to 6.00 pm, 7 days per week, or as specified in an approved construction noise management plan prepared in consultation with the DECC, or for horizontal bore drilling and construction substantially distant from residences identified during detailed design.
- Particularly important will be adherence to standard DECC recommended hours for any blasting activities required.
- When working adjacent to schools, scheduling of noisy activities to outside of normal school hours, where possible.

- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers would also result in reduced noise emissions.
- Where possible, the offset distance between noisy plant items and nearby noise sensitive receivers should be as great as possible.
- Regular compliance checks on the noise emissions of all plant and machinery used for the project would indicate whether noise emissions from plant items were higher than predicted.
- Ongoing noise monitoring during construction at identified sensitive receivers during critical periods (ie times when noise emissions are expected to be at their highest - eg chain or wheel trenching) to identify high risk noise events.
- Prepare a construction noise management plan to detail how construction noise and vibration impacts would be minimised and managed.

Source Noise Control Strategies

- Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, graders, excavators, trucks, etc. In order to minimise noise emissions, residential grade mufflers should be fitted on all mobile plant utilised on site.
- Regular maintenance of all plant and machinery used for the project will assist in minimising noise emissions.
- In particular as the chain/wheel trenchers have been identified as a dominant source during trenching contractual specifications for maximum noise emission should be considered.
- Acoustic enclosures of plant items, if required, as identified during compliance monitoring.

Noise Barrier Control Strategies

Temporary noise barriers are recommended where feasible, between the noise sources and all nearby potentially affected noise sensitive receivers, wherever possible. Typically, 7 dBA to 15 dBA of attenuation can be achieved with a well constructed barrier.

Community Consultation

Active community consultation and the maintenance of positive relations with schools, local residents and building owners would assist in alleviating concerns and thereby minimising complaint.

Prior advice will be given to the community regarding any works outside standard construction hours.

The above strategies will result in noise level reductions ranging:

- From 10 dBA in instances where space requirements place limitations on the attenuation options available.
- To potentially over 30 dBA where equipment controls (enclosures, silencers, etc) can be combined with noise barriers and management techniques (eg avoidance of clustering).

5 BLAST NOISE AND VIBRATION IMPACT

Blasting will be required to form the trench in areas of rock. This is anticipated to be concentrated in the Liverpool Ranges and in some areas on the northern edge of the Hunter Valley region.

Whilst Heggies has not been provided with details of the blast parameters and design, it is assumed drill and blast techniques incorporating confined blasting will be employed. Furthermore, Heggies has assumed typical blast parameters in order to conduct a qualitative assessment. These blast parameters will be required to be reviewed to enable a further detailed assessment once the blast design is confirmed. The typical parameters assumed are presented in **Table 13**.

Table 13 Indicative Blast Design Details

Parameter	Free-Face
Bench height	4.2 m
Stemming (using 20 mm aggregate)	2.7 m
Blasthole diameter	102 mm
Blasthole spacing	3.0 m
Burden	3.0 m
Maximum Instantaneous Charge (MIC)	11 kg

5.1 Blast Emission Levels

The blast design, consisting of 102 mm diameter blastholes on a 3 m x 3 m pattern allows one blasthole per delay producing a maximum instantaneous charge (MIC) of 11 kg in areas of shallow cover. For the majority of blasting however, the hole depth will likely be 3.0 m with 1.0 m of explosive giving an MIC of 7 kg.

By adopting the nominated typical blast design, the level of blast emissions can be predicted using the formula given in the AS 2187-2, 2006 and ICI Explosives Blasting Guide, applicable to blasting in average rock. Also given in the Guide is a formula in relation to the prediction of airblast emissions. Both methods of blast emission estimation are considered conservative.

The relevant formulae are as follows:

PVS = 1140 (R/Q ^0.5)^-1.6

dB = $164.2 - 24(\log_{10} R - 0.33 \log_{10} Q)$

Where,

PVS = Peak Vector Sum ground vibration level (mm/s)

dB = Peak airblast level (dB Linear)

R = Distance between charge and receiver (m)

Q = Charge mass per delay (kg)

The relationship between distance and the peak vector sum (PVS) ground vibration and peak airblast from the blasting are presented in **Figure 3** and **Figure 4** respectively for an MIC of 11 kg.

Figure 3 Peak Vector Sum Ground Vibration for an MIC of 11 kg

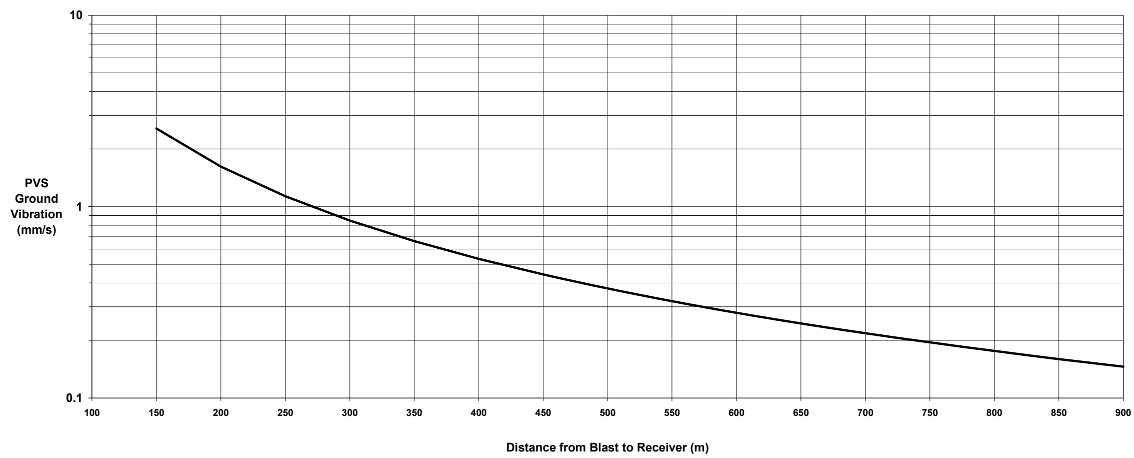
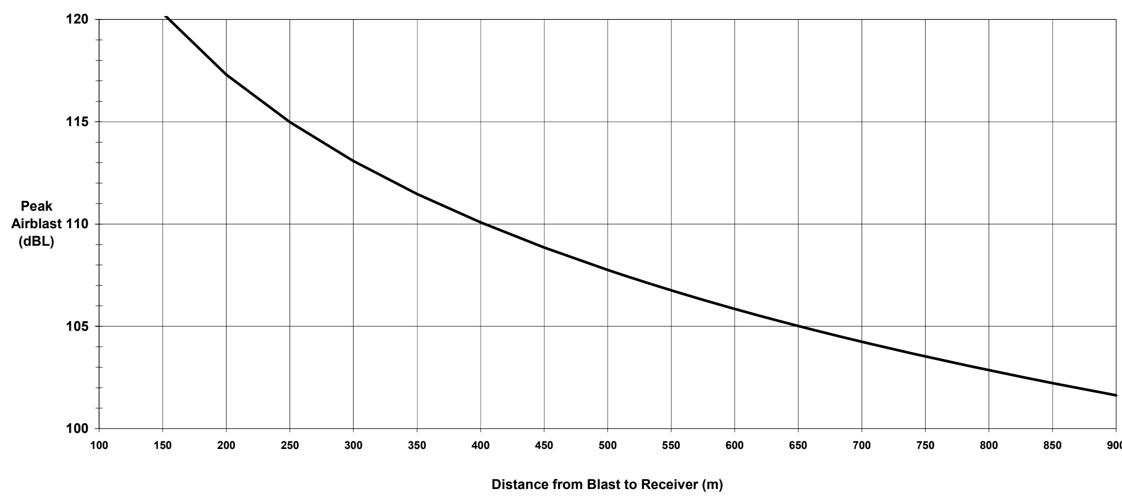


Figure 4 Peak Airblast for an MIC of 11 kg



The graphs are used to determine predicted level of blast emissions at appropriate distances to the blast site. Comparison with the criterion of 115 dBL airblast (and 5 mm peak particle velocity) indicates the complying distance to the blast emissions is determined by airblast at typically 250 m. The corresponding offset distance to comply with the criterion of 120 dBL airblast is 150 m.

For comparison, the MIC required to comply with the criterion of 120 dBL airblast (and 10 mm/s peak particle velocity) at 125 m is 6 kg.

Following identification of the potentially affected residences in the vicinity of the blast sites, refinement of the potential impacts of the typical blast designs can be reviewed.

6 CONCLUSIONS AND RECOMMENDATIONS

Heggies Pty Ltd (Heggies) has been commissioned by Manidis Roberts to assess the potential for noise and vibration impacts during construction of the proposed QHGP. This study provides a qualitative assessment of potential noise and vibration impacts and is prepared for the environmental assessment.

The QHGP will run from Wallumbilla in south central Queensland to the Newcastle area in NSW, travelling a total of 825 km in length. The results of the study are summarised in the following points:

- Design criteria for major, moderate and minor impacts have been set based on guidelines from the DECC's ENCM for construction noise, and blasting. The goals for noise have been based on assumed ambient noise levels for isolated residences, and also for rural towns.
- For the suite of construction activities expected, such as clearing, trenching pipe laying offset distances have been determined to comply with the major, moderate and minor noise criteria. Typical distances to comply with construction vibration activities have also been set.
- Blasting is proposed in the Liverpool Ranges and in some areas on the northern edge of the Hunter Valley region. Based on a typical blast design typical offset distances to comply with blasting criteria have been determined.
- Sensitive receivers (eg isolated residences, residential zones, residential zones or towns) were identified based on a desktop GIS analysis and compared to the specified offset distances to determine likely impacts.

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.

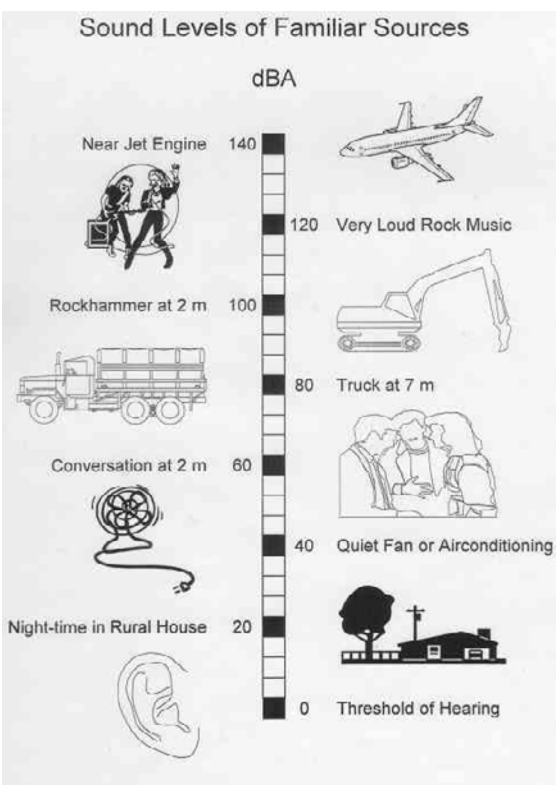
The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

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 figure below lists examples of typical noise levels



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

3 Sound Power Level

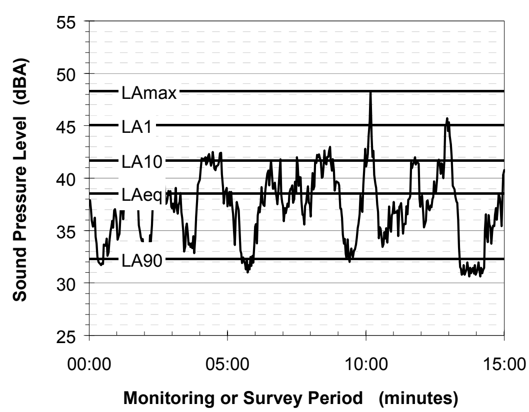
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} 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_{Amax} The maximum noise level during the 15 minute interval

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

L_{A10} The noise level exceed 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 (ie 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

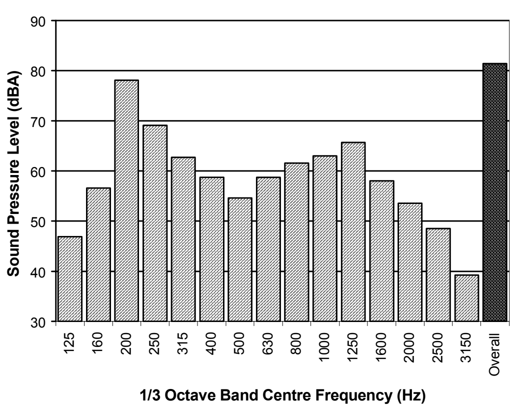
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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/V_o), where V_o 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 (ie 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 receiver through the ground and/or building structural elements, rather than through the air.

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

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

NEAREST TOWNS AND ISOLATED RESIDENCES

Location **Towns**	**Distance to the** **Pipe line(m)**	**Impact**
Kooragang	680	
Sand Gate NSW	780	
Tomago NSW	530	minor
Hinton	1260	
Wallalong	2470	
Aberdeen	2180	
Satur	2730	
Murrurundi	1000	
Ardglen	250	major
Willow Tree	940	
Quirindi	3200	
Borambil	150	major
Fredonia	410	moderate
Boonal West	760	
Teelba	740	
Beechwood	380	moderate
Billinbah	850	
Blenheim	1110	
Tinowon	480	minor
Isolated Residences		
PK687	200	major
PK685	190	major
PK671	280	major
PK672	590	moderate
PK674	120	major
PK675	280	major
PK645	600	minor
PK625	100	major
PK618	260	major
PK616	410	moderate
PK617	230	major
PK615	290	major
PK613	260	major
Pk610	283	major
PK607	470	moderate
PK603	250	major
PK595.2	300	major
PK300	70	major