22. NOISE AND VIBRATION

This chapter describes the existing noise and vibration environmental values of the study area, assesses the impacts of project construction and operation on these values and describes the avoidance, mitigation and management measures Arrow Energy will implement through project design to protect these values.

This chapter is based on the findings of the noise and vibration impact assessment conducted by Sonus Pty Ltd (Sonus) (Appendix 16, Noise and Vibration Impact Assessment).

Objectives have been developed based on relevant legislation with the aim of protecting the existing environment and environmental values. Project objectives for noise and vibration are provided in Box 22.1

Box 22.1 Objectives: Noise and vibration

- To minimise the potential for noise and vibration to adversely affect sensitive receptors during project construction and operation.
- To achieve relevant environmental noise and vibration criteria during construction and operation.
- To minimise noise and vibration impacts on terrestrial animals (including bats) and birds (avifauna) (particularly migratory species).

Noise impacts on terrestrial animals and avifauna are addressed in Chapter 17, Terrestrial Ecology. Impacts on the marine environment relating to underwater noise generated by the project are addressed in Chapter 19, Marine and Estuarine Ecology.

22.1 Legislative Context and Standards

This section outlines the specific legislation, policies and guidelines that are designed to protect the values of the environment within and surrounding the study area. These provide the framework within which the project specific noise and vibration criteria have been developed.

22.1.1 International Guidelines

The World Health Organisation (WHO) developed guidelines for community noise to protect people from annoyance during daytime (7.00 a.m. to 6.00 p.m.) and night-time hours (6.00 p.m. to 7.00 a.m.). The guidelines state that, to protect people from serious noise related annoyance during the daytime, the outdoor sound pressure level should not exceed 55 dB(A) for a steady continuous noise. To avoid sleep disturbance as a result of construction noises, the guidelines require that the noise level outside a bedroom window should not exceed 45 dB(A) (Berglund et al., 1999).

22.1.2 State Legislation, Guidelines and Standards

The legislation and guidelines that are relevant for the establishment of appropriate noise assessment conditions are outlined below:

- Environmental Protection (Noise) Policy 2008 (EPP (Noise)). This policy defines the environmental noise values for sensitive receptors. The environmental values to be enhanced or protected under this policy are:
  - The qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems.

  - The qualities of the acoustic environment that are conducive to human health and wellbeing, including ensuring a suitable acoustic environment for individuals to sleep, study, learn or be involved in recreation (including relaxation and conversation).
  - The qualities of the acoustic environment that are conducive to protecting the amenity of the community.

  The EPP (Noise) will be used as the main method of assessing noise from the project at sensitive receptors during the day, evening and night-time periods. The daytime period defined by the policy is between 7.00 a.m. and 6.00 p.m., the evening is between 6.00 p.m. and 10.00 p.m., and the night-time period is from 10.00 p.m. until 7.00 a.m.

  The EPP (Noise) does not include any provisions for construction noise limits during daytime hours. However, all reasonable and practical measures are to be taken to reduce the noise impact on sensitive receptors.

- Draft guidelines for the assessment of low-frequency noise (DERM, 2002b). This guideline provides criteria for the assessment of low-frequency, project-generated noise. For non-tonal, low-frequency noise between 20 and 200 Hz, the draft guideline states that the noise is acceptable if the contribution of low-frequency noise indoors at a sensitive receptor does not exceed 20 dB(A) during the evening or night, and 25 dB(A) during the day.
- Noise measurement manual (EPA, 2000). This manual sets out the noise measurement procedures and methodology. Noise measurements performed during the impact assessment were made in accordance with this manual.
- Planning for noise control guidelines (DERM, 2004). These guidelines provide the methods used for this impact assessment in determining background noise levels (based on site-specific noise monitoring data).
- AS 2436-1981: Guide to noise control on construction, maintenance and demolition sites. These standards detail the typical equipment and the maximum sound power levels of equipment at general construction sites. This information was used as the basis for construction noise propagation modelling and the estimation of project noise levels at a given sensitive receptor.

The standards that are relevant to the construction and operational phases of the project in relation to vibration are:

- AS 2670.2-1990: Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock induced vibration in buildings (1 to 80 HZ). This standard provides the magnitude of vibration that approximates the human threshold of perception. To guarantee human comfort and prevent complaints due to annoyance, vibration measurements should be below the levels outlined in this standard.
- DIN 4150.3-1999: Structural vibration - Part 3: Effect of vibration on structures. This standard outlines both intermittent and continuous acceptable vibration levels to ensure the structural stability of various building types.

Any blasting activities that occur during construction will generate noise and ground vibration and, potentially, flyrock. The relevant legislation and guidelines to address blasting are outlined below:

- *Environmental Protection Act 1994*. The act states that a person must not conduct blasting if:
  - The airblast pressure is more than 115 dB Z peak for 4 out of any 5 consecutive blasts.

  - The airblast overpressure is more than 120 dB Z peak for any blast.
  - For ground vibrations greater than 35 Hz, more than 25 mm/s ground vibration, peak particle velocity.
  - For ground vibrations of no more than 35 Hz, more than 10 mm/s ground vibration, peak particle velocity.

- Guidelines for blasting noise and vibration (DERM, 2006). This Queensland guideline includes the following provisions on noise and vibration criteria. Blasting activities must be undertaken in a way that, if blasting noise does affect a sensitive receptor, then:
  - The airblast overpressure must be no more than 115 dB (linear) peak for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts.
  - The airblast overpressure must not exceed 120 dB (linear) peak for any blast.

  Blasting operations must also be carried out in a way that, if blasting vibration does affect a sensitive receptor, then:

  - The ground-borne vibration must not exceed a peak velocity of 5 mm/s for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts.
  - The ground-borne vibration must not exceed a peak particle velocity of 10 mm/s for any blast event.

22.2 Assessment Method

This section describes the noise and vibration impact assessment study method. Noise related legislation, regulations and guidelines have been used to establish project-specific noise and vibration criteria that the project will meet during construction and operation. This approach allows project impacts to be defined in direct terms, i.e., if project noise and vibration criteria are met under the relevant legislation, impacts on sensitive receptors are acceptable.

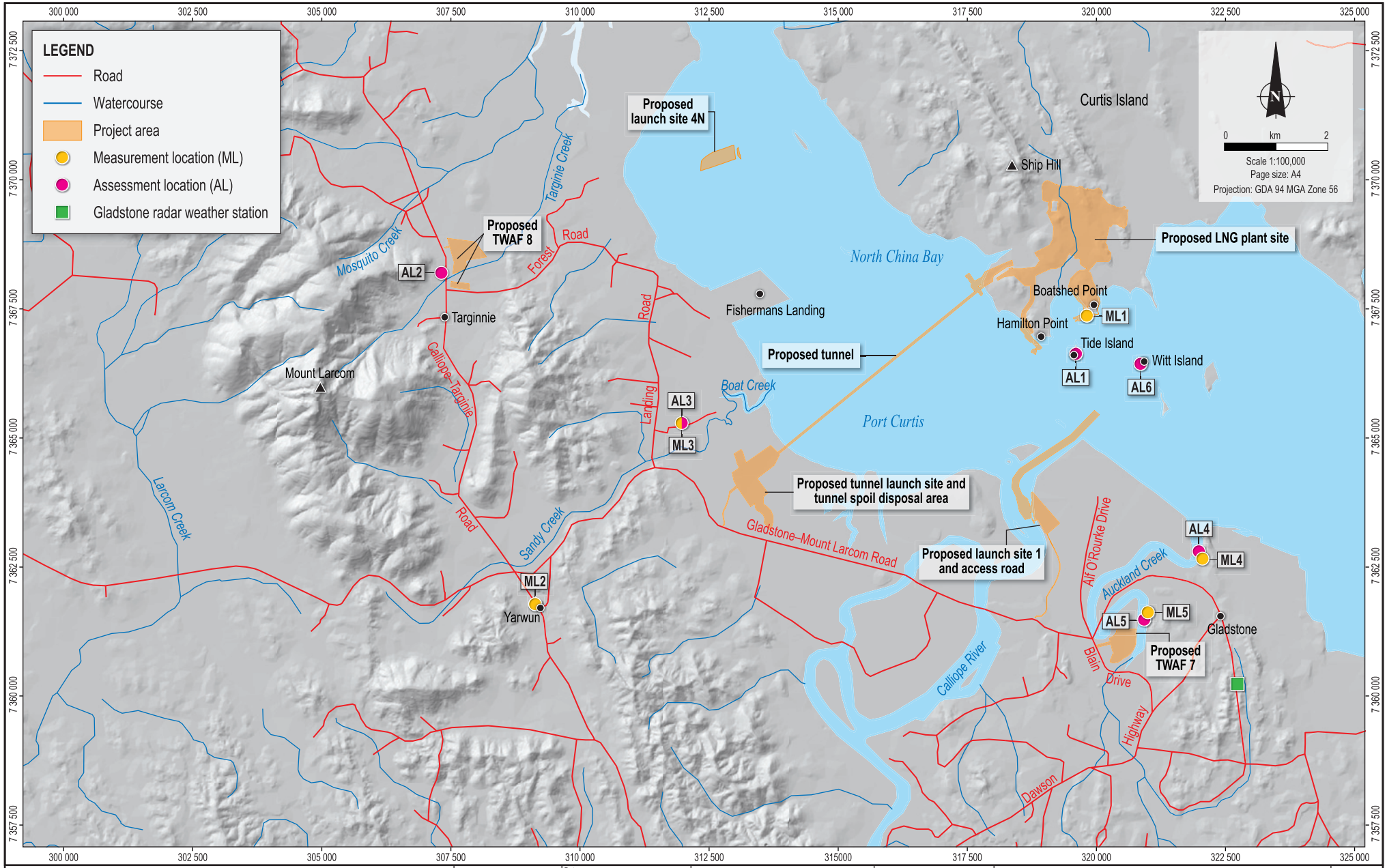
The study established environmental values, identified sensitive receptors and assessment locations, characterised existing (i.e., baseline) noise, vibration and meteorological conditions in the study area, established project specific noise and vibration criteria, and predicted noise and vibration levels that will occur due to project construction and operation.

An impact assessment on blasting has not been performed. Construction blasting requirements will be determined after further site investigations have been completed and the civil design is more advanced. General recommendations for blasting management and mitigation methods to be implemented during construction blasting activities have been described.

22.2.1 Identification of Sensitive Receptors and Assessment and Measurement Locations

Sensitive receptors are land uses (generally residences) that have the potential to experience impacts from the project. Receptors sensitive to noise and vibration impacts have been identified due to their proximity to project infrastructure (e.g., temporary workers accommodation facilities (TWAFs), launch sites, the LNG plant).

Six sensitive receptors were identified as ‘assessment locations’ (ALs), and they represent the range of sensitive acoustic environments found within the Gladstone region (Figure 22.1).



Source:
Place names, roads and watercourses from DME.
Measurement and assessment locations from Sonus.
Weather station from BOM.
Project area and digital elevation model from Coffey Environments.

coffey environments

Date: 14.11.2011
MXD: 7033CA_07_GIS121_v1_5
File Name: 7033_07_F22.01_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Noise measurement and assessment locations

Figure No: 22.1

Compliance with the assessment criteria at these six ALs will ensure compliance at all potentially affected sensitive receptors.

While ALs represent specific sensitive dwellings, measurement locations (MLs) represent where land access was possible for measurement and monitoring activities. These locations were selected for exhibiting similar existing acoustic conditions as the ALs. The relationship between the noise measurement locations and sensitive receptor assessment locations is shown in Table 22.1 and Figure 22.1.

22.2.2 Noise Impact Assessment Method

An explanation of noise level descriptors used for characterising (and assessing impacts on) the noise environment is given below:

- LA_{eq} – the A-weighted equivalent continuous sound level is defined as the steady sound level that contains the same amount of acoustic energy as a given time varying sound over the same measurement interval. It can be loosely thought of as the 'average' or 'ambient' level. The A-weighting was designed to replicate the response of the human ear and is now commonly used for the measurement of environmental and industrial noise.
- LA_{90} – the A-weighted sound level exceeded for 90% of a given measurement interval and is representative of the average minimum sound level. It is often used to describe the 'background' level.
- Rating background level – the overall single figure background noise level representing each assessment period (day, evening and night) over the whole monitoring period. The rating background level is the baseline noise level used for the assessment of impacts.

Baseline Assessment

Noise monitoring was performed at five locations (see Figure 22.1) to characterise existing background (LA_{90}) and ambient (LA_{eq}) noise levels from anthropogenic sources (e.g., vehicles, industry, etc.) and natural sounds such as the wind, ocean waves and wildlife. This data was used to calculate the rating background level. The five noise monitoring locations are representative of existing acoustic conditions at the sensitive receptors. Periods of measurement at each location are shown in Table 22.1.

Table 22.1 Baseline measurement period

Measurement Location	Associated Sensitive Receptor Assessment Location	Measurement Period	
		Start	End
ML1 (Boatshed Point)	AL1 (Tide Island), AL6 (Witt Island)	29 March 2010	14 April 2010
ML2 (Yarwun)	AL2 (Targinnie)	29 March 2010	14 April 2010
ML3 (Fishermans Road)	AL3 (Fishermans Road)[1]	1 April 2011	14 April 2011
ML4 (Lord Street)	AL4 (Lord Street)[2]	1 April 2011	14 April 2011
ML5 (Flinders Street)	AL5 (Flinders Street)[3]	1 April 2011	14 April 2011

Note: Background noise was measured at ML3 to ML5 at a later date as these sites were included in the study area later in the project.

[1] ML3 (Fishermans Road) and AL3 (Fishermans Road) are at the same location.

[2] ML4 (Lord Street) and AL4 (Lord Street) are at the same location.

[3] ML5 (Flinders Street) and AL5 (Flinders Street) are at the same location.

Impact Assessment

The characterisation of existing noise conditions enabled noise criteria for the construction and operation of the project to be developed in accordance with the EPP (Noise) and Berglund et al.

(1999) guidelines for community noise. Project construction and operation noise criteria are provided in Table 22.2.

Table 22.2 Proposed project noise criteria for construction and operation

Activity	Source	Assessment Location	Outdoor Noise Criterion (dB(A))		
			Day	Evening	Night
Construction	Construction of LNG plant, marine facilities, feed gas pipeline and dredging	AL 1	All reasonable and practical measures will be implemented to reduce noise impacts.		45
		AL 2			
		AL 3			
		AL 4			
		AL 5			
		AL 6			
Operation (continuous)	LNG plant	AL 1	33		
		AL 6			
		AL 3			
		AL 2	28		
		AL 4			
		AL 5			
Operation (intermittent)	LNG carrier movements	AL 1	50	50	45
		AL 2			
		AL 3			
		AL 4			
		AL 5			
		AL 6			

Construction noise limits are not specified in the *Environmental Protection Act 1994* or the EPP (Noise). However, amenity must be preserved during the night period at sensitive receptors, and reference is made to the WHO guidelines (Berglund et al., 1999), which state that noise during night-time periods should not exceed 45 dB(A) outside a dwelling.

Continuous operation noise criteria for the LNG plant have been developed with the aim of avoiding cumulative impacts. Background noise levels at AL1, AL3 and AL6 were high, mostly due to natural noise sources such as wind in trees and waves. A noise criterion of 33 dB(A) is therefore proposed at these locations, which accounts for the cumulative noise from other developments in the area. Background noise levels at AL2, AL4, and AL5 were lower. The selected criterion of 28 dB(A) for these receptors allows for three developments to contribute equally to achieve a cumulative noise level of 33 dB(A).

Intermittent operational noise criteria have been based on the EPP (Noise). Meeting these criteria should preserve health and well-being, and avoid sleep disturbance at sensitive receptors.

Noise impacts were modelled using the internationally recognised Conservation of Clean Air and Water in Europe (CONCAWE) noise propagation model (Manning, 1981). The CONCAWE model takes into account the effects of terrain, locations of sensitive receptors and meteorological conditions. Meteorological conditions used in the model have been based on the CONCAWE system and are classified into six weather categories:

- Category 1, 2 and 3 – wind blowing from the sensitive receptor towards the noise source during daytime with little or no cloud cover.
- Category 4 – neutral weather conditions of no wind and an overcast day or night.
- Category 5 – no wind on a clear night (typical of a temperature inversion and greater noise propagation than during Category 4 conditions).
- Category 6 – 'worst-case' conditions, when wind is blowing from the source toward the sensitive receptor on a clear night (typical of a temperature inversion).

Wind blowing from the source to a receptor (i.e., Category 5 or 6) will generate higher noise levels at the receptor than during Category 1 to 4 conditions at speeds up to 5 m/s. At higher speeds, the noise of operating equipment is typically masked by the noise of wind in trees.

Twelve months of data from the Bureau of Meteorology for the Gladstone radar weather station was analysed to determine the percentage of time each CONCAWE weather category occurred at various sensitive receptors. The selection of appropriate assessment meteorological conditions is based on this data.

Construction

Noise emissions from construction equipment are based on typical equipment likely to be used during construction, taken from the Australian standard AS 2436-1981.

While not representative of typical construction activity, a conservative approach of continuous and simultaneous equipment operation was adopted for the noise impact assessment. Noise levels generated during construction of trains 1 and 2 will be similar to the combined noise levels generated during construction of trains 3 and 4 while trains 1 and 2 are operating.

Operation

Noise levels generated during operation will vary depending on whether the LNG plant is powered by onsite gas turbine generators or by the power taken from the Queensland electricity grid. Four worst-case scenarios were assessed:

- Scenario 1: base case mechanical drive with two LNG trains operating.
- Scenario 2: all-electric power with two LNG trains operating.
- Scenario 3: base case mechanical drive with four LNG trains operating.
- Scenario 4: all-electric power with four LNG trains operating.

For each scenario, continuous and intermittent noise sources were assessed. Continuous noise sources comprise plant and equipment that, under normal operating conditions, will occur 24 hours per day. Intermittent noise will occur over shorter periods (i.e., not continuous), typically from sources such as LNG carriers and tug boats.

Continuous and intermittent noise sources such as the LNG plant and associated equipment could generate low-frequency noise. A frequency analysis of all noise sources was conducted to assess impacts of low-frequency noise on assessment locations. The draft guidelines for assessing low-frequency noise (DERM, 2002b) have been used to assess this noise type.

22.2.3 Vibration Impact Assessment Method

Levels of vibration are a result of the acceleration of a particle and its frequency; measured vibration levels for an object are measured along the x (horizontal), y (horizontal) and z (vertical) planes. The human threshold of vibration is outlined in AS 2670.2-1990.

Baseline Method

Manual vibration monitoring was performed at monitoring locations ML1 and ML2 on 14 April 2010 in accordance with AS 2670.2-1990.

The existing vibration levels at all measurement locations were well below the threshold of human perception and were not detectable without vibration measuring equipment. Measured vibration levels at ML1 and ML2 confirmed that the vibration levels were below the threshold of human detection.

Based on the observations and vibration measurements, the existing vibration levels at all other assessment locations were assumed to be below the threshold of human detection. This is a conservative approach as the project will not use existing levels of vibration to justify higher vibration from the project. Rather, the project will need to achieve the stringent vibration criteria that are unrelated to existing levels.

Impact Assessment

Vibration criteria for project construction and operation were developed in accordance with DIN 4150.3-1999, which provides criteria to assess structural damage impacts as a result of vibration from the project.

Project-specific vibration criteria for construction and operation are provided in Table 22.3 and include intermittent and continuous acceptable vibration levels for dwellings. These vibration levels were used to assess impacts associated with project construction and operation.

Table 22.3 Vibration levels for dwellings

	Vibration Level (mm/s)			
	Foundation of Dwelling			Horizontal Plane at Highest Floor of Dwelling
	1 to 10 Hz	10 to 50 Hz	Above 50 Hz	
Intermittent (construction)	5	5 to 15	15 to 20	15
Continuous (operation)	n/a	n/a	n/a	5

Source: DIN 4150.3-1999.

Impacts on human comfort were not assessed for project construction because these impacts are intermittent in nature. Structural damage due to vibration was assessed during construction. Impacts on both human comfort and structural damage were assessed during operation.

Predicted project construction and operation vibration levels used in the impact assessment were based on previous measurements of activity during the construction and operation of analogous projects.

The potential for ground vibration effects on underground pipelines and telecommunication lines was also examined.

22.3 Existing Environment and Environmental Values

Existing noise and vibration conditions are controlled by different factors across the study area. The natural sounds from waves and wind in the trees, as well as marine traffic noise, dominate conditions within Port Curtis. In the urbanised and industrialised areas of Gladstone, local road traffic and existing industry and commerce influence conditions. Further west of Gladstone in the more rural areas, road traffic, lighter industry and natural sounds influence the acoustic environment.

22.3.1 Noise

The results of noise measurements are summarised in Table 22.4 and show the calculated rating background levels for all noise monitoring locations.

Table 22.4 Calculated rating background levels

Noise Monitoring Location	Associated Impact Assessment Location	Rating Background Level (dB(A))		
		Day	Evening	Night
ML1	AL1, AL6	44	41	43
ML2	AL2	34	34	33
ML3	AL3	42	44	43
ML4	AL4	39	37	35
ML5	AL5	40	36	35

Note: Daytime – 7.00 a.m. to 6.00 p.m., Evening – 6.00 p.m. to 10.00 p.m., Night-time – 10.00 p.m. to 7.00 a.m.

22.3.2 Vibration

The existing vibration levels measured at ML1 and ML2 show that levels are below the thresholds of human perception.

No other activities near the project area (such as major roads and quarrying activities) were found to cause background levels of vibration.

22.4 Issues and Potential Impacts

This section describes the activities that will create noise and vibration during project construction and operation, and resulting impacts, prior to implementing measures to attenuate noise.

22.4.1 Noise

Construction noise sources are discussed for the LNG plant site, laydown areas and construction camps, marine facilities, feed gas pipeline and dredging activities.

The operation of the LNG plant will generate both continuous and intermittent noise.

Construction

During construction, noise will be generated at all work sites as described below.

- LNG plant site, lay down areas and construction camps:
  - Site preparation and earthmoving: Heavy construction vehicles and equipment will include bulldozers, scrapers, front-end loaders, backhoes, graders, rollers, dump trucks and water carts.
  - Civil works and plant fabrication: Concrete plant, installation of foundation structures and paved areas within the LNG plant site will require equipment such as pile drivers, heavy rollers, dump trucks, concrete trucks, generator sets and steel reinforcement fabrication hand tools including grinders and welders.
  - Construction and use of the haul road between the materials offloading facility (MOF) and LNG plant: Equipment will include excavators, graders, rollers and dump trucks.
  - Construction of the LNG plant: Activities such as receiving and transporting large plant items (modules) from the MOF to the LNG plant site will typically require equipment such as tugs and barges, offloading crawler cranes and heavy transport equipment. Onsite steel

fabrication and pipe erection will typically require equipment such as tower cranes, grinders, welders, generator sets and air compressors. Erection and assembly of plant items will require equipment such as tower cranes, forklifts, generator sets and air compressors.

Temporary elevations in the noise profile may occur from blasting, in addition to routine construction noise. The blasting events will likely occur at irregular intervals.

- Marine facilities (MOF and personnel jetty, LNG jetty and mainland launch site):
  - The work will require heavy construction equipment such as excavators, bulldozers, dump trucks, graders, rollers and concrete trucks. Piling will be required for the MOF and personnel jetty.
  - Site preparation and earthmoving activities: These will be carried out by heavy construction vehicles and equipment such as bulldozers, scrapers, front-end loaders, backhoes, graders, rollers, dump trucks and water carts.
  - Construction of the MOF, LNG jetty and mainland launch sites: Construction will typically require equipment such as pile drivers and cranes.
  - Dredging at all marine infrastructure sites to assist construction activities: Cutter suction and backhoe dredgers will be used, supplemented by barges and support tender vessels.
- Feed gas pipeline:
  - Open cut trenching: Noise will be produced from equipment such as front-end loaders, welders, trenching machines, excavators, trucks, cranes and concrete mixers.
  - Tunneling: Ancillary equipment such as slurry pumps will generate noise during construction of the feed gas pipeline Port Curtis tunnel crossing.

Table 22.5 shows predicted noise levels at the impact assessment locations due to construction activities.

Modelling of construction noise predicts that construction noise criteria will be exceeded at sensitive receptor assessment locations AL1 and AL5 during night-time periods. Sensitive receptor assessment location AL1 will be adversely affected during construction of the LNG plant, MOF and personnel jetty (for both the Boatshed Point and South Hamilton Point options) and the construction camps on Curtis Island. Noise criteria at sensitive receptor assessment location AL5 will only be exceeded during construction of TWAF 7.

Construction noise levels at all other sensitive receptor assessment locations (AL2, AL3, AL4 and AL6) will comply with project noise criteria.

Operation

Operation noise sources are classified as either continuous (noise sources which operate continuously over a 24-hour period) or intermittent (noise sources that will only occur for short-term periods). The main continuous noise source during operation will be fixed equipment at the LNG plant (i.e., LNG trains, gas turbines for the mechanical drive option, water facilities, loading systems, substations, etc.).

Table 22.5 Predicted noise levels during construction

Assessment Location	Construction Area									
		Marine Facilities*					Feed Gas Pipeline	Construction Camps		
	LNG Plant	Boatshed Point MOF and Personnel Jetty	South Hamilton Point MOF and Personnel Jetty	LNG Jetty	Launch Site 1	Launch Site 4N		Curtis Island	TWAF 7	TWAF 8
AL1*	***47***	***63***	***58***	43	42	n/a	27	***53***	n/a	***62***
AL2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AL3	n/a	n/a	n/a	n/a	n/a	28	40	n/a	n/a	n/a
AL4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AL5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	***61***	n/a
AL6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Assessment Location	Construction Area									
	Laydown Areas					Dredge Sites				
	Curtis Island	Launch Site 1	Launch Site 4N	Curtis Island and Launch Site 1	Curtis Island and Launch Site 4N	Launch Site 1	Launch Site 4N	Boatshed Point	Hamilton Point South	LNG Jetty
AL1*	44	33	23	44	44	28	18	***53***	***50***	33
AL2	17	10	20	18	22	5	12	12	8	14
AL3	27	18	19	27	27	13	12	22	21	25
AL4	31	27	15	32	31	18	11	29	25	24
AL5	26	30	15	31	26	23	11	23	19	21
AL6	42	31	20	42	42	24	16	45	39	30

Note:

n/a – sites that are too far away from construction noise sources to be impacted.

Bold italicised numbers indicate noise levels that exceed the proposed construction night-time noise criteria of 45 dB(A).

*The noise from construction of the marine facilities was assessed at the closest sensitive receptor (AL1) on the basis that the noise at all other locations would be lower.

Modelling results for the four LNG plant operation scenarios are provided in Table 22.6. The bold italicised numbers indicate noise levels that exceed the proposed project noise criteria. Operational noise levels at sensitive receptor assessment locations AL1, AL4 and AL6 will exceed project noise criteria under all scenarios; operational noise levels at sensitive receptor AL3 will exceed project noise criteria under Scenario 3; and operational noise levels at sensitive receptor AL5 will exceed project noise criteria under Scenarios 3 and 4, i.e., when four LNG trains are operating, regardless of how the LNG plant is powered.

Table 22.6 Predicted noise levels from continuous operation activities

Assessment Location	Noise Criterion dB(A)	Predicted Operational Noise Level dB(A)			
		All Mechanical Drive		All Electrical Power	
		Two LNG Trains (Scenario 1)	Four LNG Trains (Scenario 3)	Two LNG Trains (Scenario 2)	Four LNG Trains (Scenario 4)
AL1	33	***47***	***49***	***46***	***48***
AL2	28	22	25	20	23
AL3	33	31	***34***	30	33
AL4	28	***34***	***37***	***33***	***35***
AL5	28	28	***31***	27	**29**
AL6	33	***45***	***47***	***44***	***46***

The noise from the LNG plant equipment is not dominated by low-frequency noise, but is made up of a combination of high, mid and low frequency noises. As high and mid frequency noise attenuates faster over large distances, a greater component of low-frequency noise will be received at sensitive receptors. The DERM (2002b) Low Frequency Noise Draft Guideline recommends acceptable levels of 20 dB(A) low-frequency noise within a dwelling. The predicted low-frequency noise levels will be exceeded during operation.

Intermittent noise during operation, including LNG carriers and tug boats, will not exceed the project noise criteria.

22.4.2 Vibration

Construction vibration sources are discussed for the LNG plant site, construction camps, marine facilities and the feed gas pipeline. Vibration sources during operation are discussed for the LNG plant, LNG jetty, and the feed gas pipeline.

Construction

Construction activities will cause vibrations at the following worksites.

- LNG plant site and construction camps:
  - Civil works, foundations and plant fabrication: Equipment such as heavy rollers, dump trucks, concrete trucks and generators will be involved. Piling will also be required to construct the plant foundations.
  - Construction of the LNG jetty: This work will typically require equipment such as pile drivers.
  - Intermittent blasting activities.
- Marine facilities (MOF and personnel jetty, LNG jetty and mainland launch site):

  - Construction: Heavy construction equipment will be used, such as excavators, bulldozers, dump trucks, graders, rollers and concrete trucks. Sheet piling will be required for the MOF and personnel jetty.
  - Dredging: This work will involve cutter suction and backhoe dredgers and associated support vessels.
- Feed gas pipeline:
  - Open cut trenching. Equipment such as front-end loaders, excavators, trucks, cranes and concrete mixers will be required.
  - Tunneling. Ancillary equipment such as slurry pumps will be used during construction of the feed gas pipeline Port Curtis tunnel crossing.

The distance between the LNG plant construction site and the closest sensitive receptor assessment location at AL1 is 2.4 km, and vibration levels will be well below the threshold of human detection. Therefore, the remaining assessment locations will similarly be unaffected as they are even further away.

Vibration levels during construction will not impact on pipework or telecommunication lines within the project vicinity because none currently exist.

Similarly, separation distances between all assessment locations and other construction sites and activities (marine facilities, construction camps, the feed gas pipeline alignment and dredging) are such that expected vibration levels will also be below the threshold of human detection.

Operation

Vibration at assessment locations during the operation of the project may be generated by the operation of equipment at the LNG plant, LNG jetty and the feed gas pipeline. Vibration levels will be well below the threshold of human detection due to the large separation distances of all assessment locations from this infrastructure.

The feed gas pipeline will be located underground and the associated equipment is not expected to produce a perceivable vibration on the land surface. Any underground pipework or telecommunication lines located near the feed gas pipeline will not be structurally damaged as a result of vibration. The vibration levels at assessment locations in the vicinity of the feed gas pipeline are predicted to be well below the threshold of human detection.

22.5 Avoidance, Mitigation and Management Measures

This section describes the proposed avoidance, mitigation and management measures designed to ensure compliance with noise and vibration criteria.

22.5.1 Noise

Construction mitigation measures will make use of attenuation devices on machinery, correct handling and usage of noise generating equipment, and scheduling and coordination of the use of noisy equipment during daytime periods.

Mitigation measures for operation focus on the acoustic treatments that will reduce noise impacts when applied to the LNG plant and ancillary facilities.

Construction

The following management and mitigation measures will be implemented to reduce construction noise below the project criteria of 45 dB(A) during the night-time period:

- Where practical, locate noise making equipment to maximise the distance between noise sources (e.g., diesel generators) and sensitive receptors. The use of structures or natural topography to create barriers to noise may be used to lessen the noise impacts on sensitive receptors. [C22.02]
- Regularly maintain all machinery and equipment and check for excessive noise generation. [C22.04]
- Where noise from a construction activity would exceed the project night time noise criteria of 45 dB(A) at a sensitive receptor, schedule, where practical, construction activities to occur between 7.00 a.m. and 10.00 p.m. [C22.05]
- Continually review the timing of construction activities to identify opportunities to reschedule concurrent activities where excessive noise is expected. [C22.06]

Operation

Compliance with operational project noise criteria will require the application of acoustic treatments. The potential treatment options to achieve compliance provided in Table 22.7 are conceptual only, and are specified here to enable modelling of noise contours for the purposes of the residual impact assessment. Arrow Energy will identify, during the detailed design of the LNG plant, specific acoustic treatment to be applied to each noise source. [C22.01]

Table 22.7 Potential acoustic treatments

Noise Source	Potential Acoustic Treatment
LNG Train Equipment (per LNG Train)	
Process Compressors	
Low-pressure compressor	Sheet steel enclosure with acoustically treated ventilation.
Low-, medium- and high-pressure compressor	Sheet steel enclosure with acoustically treated ventilation.
Gas turbine casing (100 MW)	Sheet steel enclosure with acoustically treated ventilation.
Gas turbine exhaust stack (100 MW)	Upgrade silencer.
Air Coolers	
Fan bay (3 fans)	Use of ultra-low noise fans, installation of variable fan drives, incorporation of discharge air sound attenuators.
End Flash Gas Compression Unit	
Compressor electric motor	Sheet steel enclosure with acoustically treated ventilation.
Other Equipment at LNG Plant	
Power Generator Drives	
Gas turbine casing (30 MW)	Sheet steel enclosure with acoustically treated ventilation.
Gas turbine exhaust stack (30 MW)	Upgrade silencer.
Generator	Sheet steel enclosure with acoustically treated ventilation.
Loading System	
Boil off gas compressors	Sheet steel enclosure with acoustically treated ventilation.

Table 22.7 Potential acoustic treatments (cont'd)

Noise Source	Potential Acoustic Treatment
Other Equipment at LNG Plant (cont'd)	
Water Facilities	
High-pressure pump	Sheet steel enclosure with acoustically treated ventilation.
Pump	Sheet steel enclosure with acoustically treated ventilation.

22.5.2 Blasting Noise and Vibration

Blasting noise and vibration impacts associated with the project have not been assessed as detailed information (e.g., location, size, timing and frequency) is not yet available. Any blasting required during project construction will be confirmed and assessed as necessary at a later stage of the project.

Arrow Energy will include appropriate methods to manage blasting activities in the construction environmental management plan. If required, blasting activities will be carried out in accordance with the guidelines for blasting noise and vibration (DERM, 2006). [C22.03]

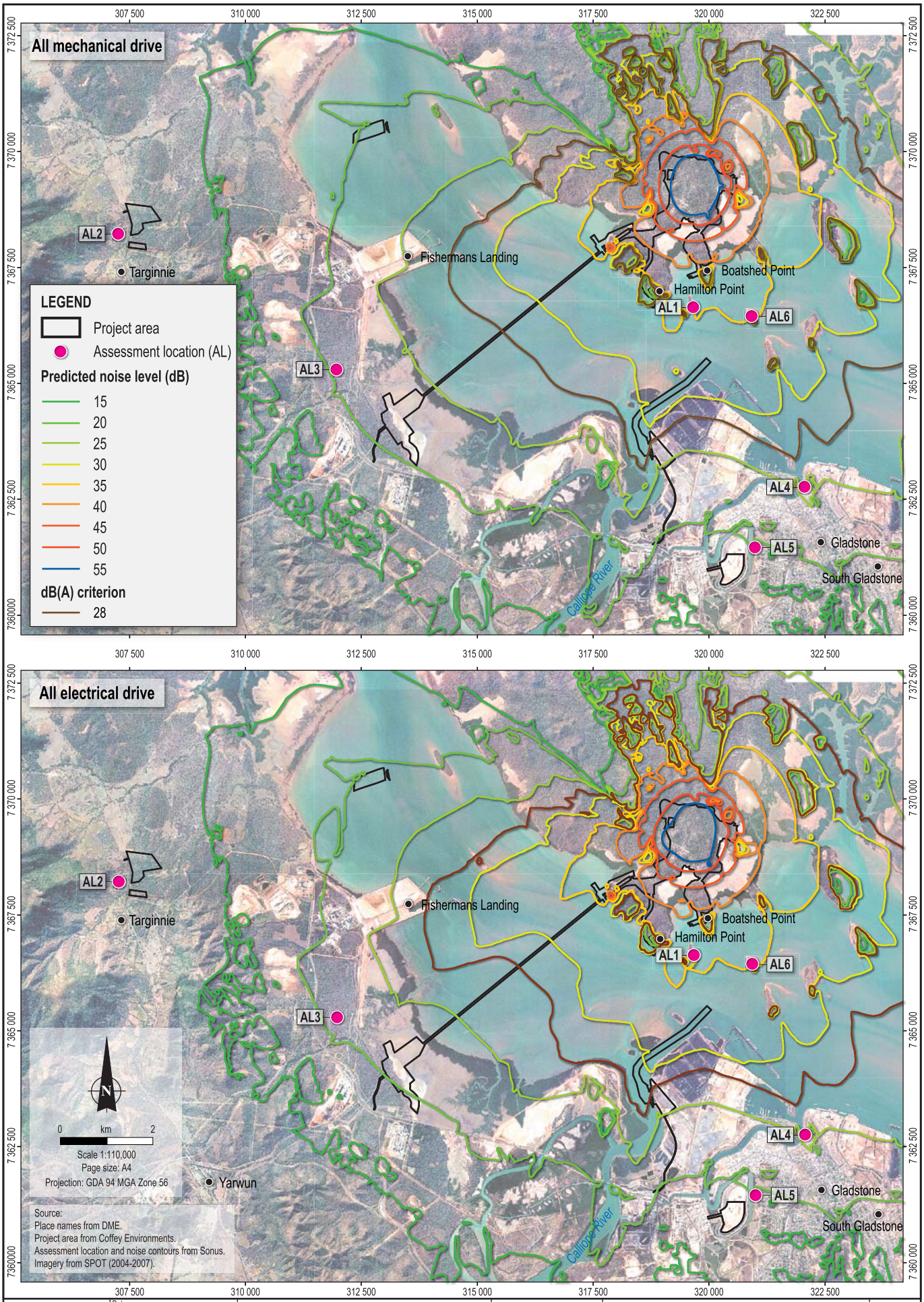
22.6 Residual Impacts

Predicted operational noise levels at each assessment location, with the potential acoustic treatments applied at the LNG plant, are provided in Table 22.8. Predicted noise contours with potential acoustic treatment are shown in Figure 22.2. Arrow Energy will ensure that project related noise generated during operation complies with the project noise criteria at all assessment locations. [C22.07]

Table 22.8 Predicted noise levels from LNG plant operation with additional acoustic treatment

Assessment Location	Noise Criterion dB(A)	Predicted Operational Noise Level dB(A)			
		All Mechanical Drive		All Electrical Power	
		Two LNG Trains	Four LNG Trains	Two LNG Trains	Four LNG Trains
AL1	33	33	33	33	33
AL2	28	11	12	11	12
AL3	33	19	20	20	21
AL4	28	22	22	22	22
AL5	28	16	16	16	17
AL6	33	31	32	31	31

The low-frequency noise levels (from operation of the LNG plant) inside the closest dwelling were predicted assuming the potential acoustic treatments were in place and neutral meteorological conditions. The predicted outcome of low-frequency noise levels at sensitive receptor AL1 for both the mechanical drive (19 dB(A)) and all-electric option (18 dB(A)) are below the indoor noise criterion of 20 dB(A) and are not expected to exceed project noise criteria. Sensitive receptor AL1 is the most affected assessment location and noise levels at all assessment locations will therefore not exceed project noise criteria for low-frequency noise.



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Noise contours of the predicted noise levels with acoustic treatment

Figure No: 22.2

Project construction and operation activities will comply with project noise criteria assuming implementation of the identified mitigation measures and acoustic treatments. As such, there are no residual noise impacts. Vibration impacts are below the threshold for human detection and, as such, there are no residual impacts.

22.7 Inspection and Monitoring

Background noise and vibration monitoring will be completed prior to construction commencing. Noise and vibration monitoring will be undertaken during the construction and operation phases on an ‘as required’ basis.

22.8 Commitments

The measures (commitments) that Arrow Energy will implement to manage impacts from noise and vibration are set out in Table 22.9.

Table 22.9 Commitments: Noise and vibration

No.	Commitment
C22.01	Identify during the detailed design of the LNG plant, specific acoustic treatment to be applied to each noise source.
C22.02	Where practical, locate noise-making equipment to maximise the distance between noise sources (e.g., diesel generators) and sensitive receptors. The use of structures or natural topography to create barriers to noise may be used to lessen the noise impacts on sensitive receptors.
C22.03	Include appropriate methods to manage blasting activities in the construction environmental management plan. If required, carry out blasting activities in accordance with the guidelines for blasting noise and vibration.
C22.04	Regularly maintain all machinery and equipment and check for excessive noise generation.
C22.05	Where noise from a construction activity would exceed the project night time noise criteria of 45 dB(A) at a sensitive receptor, schedule, where practical, construction activities to occur between 7.00 a.m. and 10.00 p.m.
C22.06	Continually review the timing of construction activities to identify opportunities to reschedule concurrent activities where excessive noise is expected.
C22.07	Ensure that project related noise generated during operation complies with the project noise criteria at all assessment locations.