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Surat Gas Project

Noise and Vibration Impact Assessment

Prepared For

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EXECUTIVE SUMMARY

An assessment has been made of the potential noise and vibration associated with the Surat Gas Project. The assessment includes the production facilities, comprising the field compression facilities (FCFs), the central gas processing facilities (CGPFs) and the integrated processing facilities (IPFs), the gas production wells, and the associated water and gas pipelines.

The assessment also provides a procedure to enable the project's environmental noise and vibration criteria to be achieved from the construction and operation of the project. Separation distances and mitigation measures have been identified in order to achieve the noise criteria based on modelled noise levels from indicatively selected equipment.

The Department of Environment and Resource Management (DERM) has released the "Coal Seam Gas Industry Procedural Guide – Control of Noise from Gasfield Activities" (the Procedural Guide). Based on this document, appropriate criteria for noise from construction and operation of the project have been proposed. The proposed criteria take into account the different scenarios of the existing noise environment at sensitive receptors, and are summarised below:

Scenario 1 – For sensitive receptors with a low noise environment.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

Scenario 2 – For sensitive receptors with background noise levels which are greater than the minimum deemed background noise level of the Procedural Guide, and have no influence from an existing Arrow Energy Pty Ltd (Arrow) plant.

Time Period	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}$ $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}$ $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}$ $L_{p,A,15mins} \leq$ 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)

Scenario 3 – For sensitive receptors with noise influence from an existing Arrow plant.

Time Period	Noise Criteria
All periods	Total noise level (new and existing Arrow plant) no greater than the existing Arrow plant noise contribution.

To objectively assess the impact of vibration from the project, direct reference has been made to the Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999, which provide criteria for human comfort and the prevention of structural damage to buildings, respectively.

The noise and vibration criteria for blasting has been based on the *Environmental Protection Act 1994 and* the DERM "Noise and vibration from blasting" Guideline.

As the sites and the equipment to be installed at the production facilities and production wells are yet to be finalised, a noise impact assessment has been conducted based on a typical site layout and indicative equipment, with the site being located in an environment typical of the project development area. The assessment indicated that the noise from the construction and operation of the project can achieve the proposed noise conditions with practicable acoustic treatment and mitigation measures.

In addition, a noise impact assessment procedure has been developed to ensure that the noise from the project achieves the proposed noise conditions at sensitive receptors and therefore does not adversely affect the environment.

The potential noise and vibration impact from off-site traffic generated by the project has been considered based on the estimated peak project-generated travel. The assessment indicated that there will be no change of impact at sensitive receptors from the anticipated increase of traffic volume on roads.

Given that direct use of rail transportation is not anticipated for the project, the potential impact from rail has not been considered in this assessment.

The cumulative noise and vibration impact of the project, existing developments, and projects with an approved environmental impact statement (EIS), which are located in the Surat Basin has also been considered. Based on the assessment, the cumulative noise at sensitive receptors can achieve the proposed noise conditions with the application of appropriate acoustic treatment to this project and allowing similar noise contribution from other projects. The cumulative vibration from the industry will not have a significant impact on sensitive receptors, given the large separation distances (i.e., greater than 100m) of sensitive receptors from the potential vibration sources.

Based on the noise and vibration impact assessments, analysis of the potential impact of noise and vibration on livestock located close to facilities has been conducted. Based on the application of appropriate acoustic treatment at the facilities (e.g., to achieve 28dB(A) at 2km from the facility), and the typical production well equipment (5.7L gas engine powered), the noise experienced by livestock outside of the site boundaries is expected to be no greater than the noise experienced when grazing adjacent to roads. No significant vibration impact is expected to be experienced by livestock.

GLOSSARY

Ambient noise level	The noise level with the presence of all noise sources
A weighting	Frequency adjustment representing the response of the human ear
Background noise level	The noise level in the absence of intermittent noise sources
Background creep	The gradual increase in background noise levels in an area as a result of successive developments generating constant noise levels at a particular location.
CONCAWE	The oil companies' international study group for conservation of clean air and water – Europe "The propagation of noise from petrochemical complexes to neighbouring communities"
CSGI	Coal seam gas industry
dB(A)	A weighted noise or sound power level in decibels
DERM	Department of Environment and Resource Management
Equivalent noise level	Energy averaged noise level
$L_{A1,adj,1hr}$	The A weighted noise level exceeded 1% of the time measured in decibels over a period of 1 hour and adjusted for tonality or impulsiveness, representing the maximum noise level
$L_{A10,adj,1hr}$	The A weighted noise level exceeded 10% of the time measured in decibels over a period of 1 hour and adjusted for tonality or impulsiveness, representing the typical upper noise level
L_{A10}	The A weighted noise level exceeded 10% of the time measured in decibels.
$L_{A10,18hr}$	The arithmetic average of 18 hourly L_{A10} measurements, measured consecutively between 6am and 12 midnight.
L_{A90}	The A weighted noise level exceeded 90% of the time measured in decibels, representing the background noise level
L_{Aeq}	The A weighted equivalent noise level measured in decibels
$L_{Aeq,\ adj,\ 1\ hour}$	The A weighted equivalent noise level measured in decibels over a period of 1 hour and adjusted for tonality
$L_{Aeq,adj,15mins}$	The A weighted equivalent noise level measured in decibels over a period of 15 minutes and adjusted for tonality
$L_{pA,LF}$	Indoor low frequency A weighted noise level measured in

	decibels
$_{max}$ $L_{p,A,15mins}$	The maximum A weighted noise level measured in decibels over a period of 15 minutes
RBL	Rating Background Level
Sensitive receptor	A location in the vicinity of the proposed development, where noise may affect the amenity of the land use. For the proposed development, sensitive receptors are generally dwellings.
Sound power level	A measure of the sound energy emitted from a source of noise.
WHO	World Health Organisation
Worst-case	Conditions resulting in the highest noise level at or inside dwellings. Worst-case meteorological conditions can be characterised as no cloud at night with wind from the project site to dwellings.

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1 INTRODUCTION

1.1 Project Proponent

Arrow Energy Pty Ltd (Arrow) is an integrated energy company with interests in coal seam gas field developments, pipeline infrastructure, electricity generation and proposed liquefied natural gas (LNG) projects.

Arrow has interests in more than 65,000 km^2 of petroleum tenures, mostly within Queensland's Surat and Bowen basins. Elsewhere in Queensland, the company has interests in the Clarence-Moreton, Coastal Tertiary, Ipswich, Styx and Nagoorin Graben basins.

Arrow's petroleum tenures are located close to Queensland's three key energy markets; Townsville, Gladstone and Brisbane. The Moranbah Gas Project in the Bowen Basin and the Tipton West, Daandine, Kogan North and Stratheden projects in the Surat Basin near Dalby comprise Arrow's existing coal seam gas production operations. These existing operations currently account for approximately 20% of Queensland's overall domestic gas production.

Arrow supplies gas to the Daandine, Braemar 1 and 2, Townsville and Swanbank E power stations, which participate in the National Electricity Market. With equity in Braemar 2, Daandine and Townsville power stations Arrow has access to up to 600 MW of power generation capacity.

Arrow and its equity partner AGL Energy have access rights to the North Queensland Pipeline which supplies gas to Townsville from the Moranbah Gas Project. They also hold the pipeline licence for the proposed Central Queensland Gas Pipeline between Moranbah and Gladstone.

Arrow is currently proposing to develop the Arrow LNG Project, which is made up of the following aspects:

- Arrow LNG Plant – The proposed development of an LNG Plant on Curtis Island near Gladstone, and associated infrastructure, including the gas pipeline crossing of Port Curtis.

- Surat Gas Project – The upstream gas field development in the Surat Basin, subject of this assessment.
- Arrow Surat Pipeline – (Formerly the Surat Gladstone Pipeline), the 450 km transmission pipeline connects Arrow's Surat Basin coal seam gas developments to Gladstone.
- Bowen Gas Project – The upstream gas field development in the Bowen Basin.
- Arrow Bowen Pipeline – The transmission pipeline which connects Arrow's Bowen Basin coal seam gas developments to Gladstone.

1.2 Project Overview

Arrow proposes expansion of its coal seam gas operations in the Surat Basin through the Surat Gas Project. The need for the project arises from the growing demand for gas in the domestic market and global demand and the associated expansion of LNG export markets.

The project development area covers approximately 8,600 km^2 and is located approximately 160 km west of Brisbane in Queensland's Surat Basin. The project development area extends from the township of Wandoan in the north towards Goondiwindi in the south, in an arc adjacent to Dalby. Townships within or in close proximity to the project development area include (but are not limited to) Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, Miles and Goondiwindi. Project infrastructure including coal seam gas production wells and production facilities (including both water treatment and power generation facilities where applicable) will be located throughout the project development area but not in towns. Facilities supporting the petroleum development activities such as depots, stores and offices may be located in or adjacent to towns.

The conceptual Surat Gas Project design presented in the environmental impact statement (EIS) is a reference case developed for the EIS, and is premised upon peak gas production from Arrow's Surat Basin gas fields of approximately 1,050 TJ/d. The peak gas production comprises 970 TJ/d for LNG production (including a 10% fuel gas requirement for facility operation) and a further 80 TJ/d for supply to the domestic gas market.

A project life of 35 years has been adopted for EIS purposes. Ramp-up to peak production is estimated to take between 4 and 5 years, and is planned to commence in 2014. Following ramp-up, gas production will be sustained at approximately 1,050 TJ/d for at least 20 years, after which production is expected to decline.

Infrastructure for the project is expected to comprise:

- Approximately 7,500 production wells drilled over the life of the project at a rate of approximately 400 wells drilled per year.
- Low pressure gas gathering lines to transport gas from the production wells to production facilities.
- Medium pressure gas pipelines to transport gas between field compression facilities and central gas processing and integrated processing facilities.
- High pressure gas pipelines to transport gas from central gas processing and integrated processing facilities to the sales gas pipeline.
- Water gathering lines (located in a common trench with the gas gathering lines) to transport coal seam water from production wells to transfer, treatment and storage facilities.
- Approximately 18 production facilities across the project development area expected to comprise of 6 of each of the following:
  - Field compression facilities.
  - Central gas processing facilities.
  - Integrated processing facilities.
- A combination of gas powered electricity generation equipment that will be co-located with production facilities and/or electricity transmission infrastructure that may draw electricity from the grid (via third party substations).

Further detail regarding the function of each type of production facility is detailed below.

Field compression facilities will receive gas from production wells and are expected to provide 30 to 60 TJ/d of first stage gas compression. Compressed gas will be transported from field compression facilities in medium pressure gas pipelines to multi-stage compressors at central gas processing facilities and integrated processing facilities where the gas will be further compressed to transmission gas pipeline operating pressure and dehydrated to transmission gas pipeline quality. Coal seam water will bypass field compression facilities.

Central gas processing facilities will receive gas both directly from production wells and field compression facilities. Central gas processing facilities are expected to provide between

30 and 150 TJ/d of gas compression and dehydration. Coal seam water will bypass central gas processing facilities and be pumped to an integrated processing facility for treatment.

Integrated processing facilities will receive gas from production wells and field compression facilities. Integrated processing facilities are expected to provide between 30 and 150 TJ/d of gas compression and dehydration. Coal seam water received at integrated processing facilities is expected to be predominantly treated using reverse osmosis and then balanced to ensure that it is suitable for the intended beneficial use. Coal seam water received from the field, treated water and brine concentrate will be stored in dams adjacent to integrated processing facilities.

It is envisaged that development of the Surat Gas Project will occur in five development regions: Wandoan, Chinchilla, Dalby, Kogan/Millmerran and Goondiwindi. Development of these regions will be staged to optimise production over the life of the project.

Arrow has established a framework to guide the selection of sites for production wells and production facilities and routes for gathering lines and pipelines. The framework will also be used to select sites for associated infrastructure such as access roads and construction camps. Environmental and social constraints to development that have been identified through the EIS process coupled with the application of appropriate environmental management controls will ensure that protection of environmental values (resources) is considered in project planning. This approach will maximise the opportunity to select appropriate site locations that minimise potential environmental and social impacts.

Arrow has identified 18 areas that are nominated for potential facility development to facilitate environmental impact assessment (and modelling). These are based on circles of approximately 12 km radius that signify areas where development of production facilities could potentially occur.

Arrow intends to pursue opportunities in the selection of equipment (including reserve osmosis units, gas powered engines, electrical generators and compressors) and the design of facilities that facilitates the cost effective and efficient scaling of facilities to meet field conditions. This flexibility will enable Arrow to better match infrastructure to coal seam gas production. It will also enable Arrow to investigate the merits of using template design principles for facility development, which may in turn generate further efficiencies as the gas reserves are better understood, design is finalised, or as field development progresses.

2 OBJECTIVES

Sonus Pty Ltd (Sonus) has been engaged to conduct an assessment of the impact of noise and vibration on the environment from the Surat Gas Project. The objectives of the assessment were:

- to establish the noise and vibration related environmental values of the study area;
- to determine appropriate environmental noise and vibration criteria;
- to establish a procedure that ensures the construction and operation of the project achieves the appropriate environmental noise criteria;
- to determine the potential impact from the construction and operation of the project, and;
- to consider the feasibility of measures to be implemented to achieve the relevant criteria.

This report addresses the Terms of Reference (TOR) pertaining to noise and vibration, and will form part of an overall environmental impact statement (EIS) for the project.

3 SCOPE

The noise and vibration impact assessment considered the following general aspects associated with the project:

- development of field infrastructure to extract water and gas from the ground and transfer to production facilities;
- development of production facilities to compress extracted gas for distribution to the market;
- development of facilities to manage water extracted from the coal seams, and;
- operation of the field infrastructure, production and distribution facilities.

Specifically, the noise and vibration associated with the following project activities were assessed in the study:

- the construction, maintenance and abandonment of the production wells;
- the construction of the associated gas and water transfer pipelines;
- the construction of the production facilities comprising the field compression facilities, central gas processing facilities and integrated processing facilities;
- the operation of the production wells and the production facilities;
- blasting during construction. At this stage, blasting is not anticipated during construction of the project, however it was included in the study, should the need later arise, and;
- off-site road traffic associated with the construction and operation of the project. Direct use of rail transportation is not anticipated for the project and therefore has not been assessed in this study.

4 METHODOLOGY

In order to appropriately address the TOR for the project, the following steps were implemented in this assessment.

4.1 Establishment of Environmental Values

To determine the existing environmental values that may be affected by noise and vibration from the project, reference was made to the Environmental Protection (Noise) Policy 2008 (EPP (Noise)), which defines the environmental values for noise-sensitive receptors. The assessment ensured that existing environmental values were identified and preserved.

4.2 Description of Existing Environment and Baseline Monitoring

Noise measurements were conducted at multiple monitoring locations to determine the existing acoustic environment of different areas within the study area (refer Figure B.1 in Appendix B). The monitoring locations were selected such that measurements at the respective locations provide indicative background noise levels at sensitive receptors, which may be affected by the project.

The baseline noise monitoring determined the existing ambient and background noise levels at sensitive receptors located within rural areas of the Surat Basin. The monitoring locations include areas with and without the influence from existing industry.

4.3 Analysis of Meteorological Conditions

The analysis of meteorological data was conducted to determine the prevalent meteorological conditions within the Surat Basin and to establish appropriate conditions for noise modelling. The meteorological conditions were specified in terms of the CONCAWE system, as the CONCAWE noise propagation model is used in this assessment.

The CONCAWE propagation model is used as it takes into account ground topography, ground absorption, air absorption and meteorological conditions, and is widely accepted around the world as an appropriate sound propagation model for predicting noise over significant distances.

The CONCAWE system categorises the possible meteorological conditions into six categories, from Category 1 to Category 6. Category 1 is considered the "best-case meteorological conditions (i.e., lowest nose level) while Category 6 is considered the "worst-case" meteorological conditions (i.e., highest noise level). The CONCAWE system is further detailed in Section 6.

4.4 Establishment of Assessment Criteria

The significance of a potential impact at sensitive receptors is determined based on Arrow's ability to achieve the appropriate assessment criteria during the construction and operation of the project. The assessment criteria are established based on the relevant legislation and guidelines, and the existing environment at sensitive receptors.

Based on the baseline monitoring and the analysis of meteorological conditions for the area, appropriate noise conditions were proposed for the operation and construction of the project. The proposed noise conditions are in accordance with the following legislation and guidelines:

- the *Environment Protection Act 1994;*
- the Environmental Protection (Noise) Policy 2008;
- World Health Organisation (WHO) Guidelines 1999;
- DERM "Coal Seam Gas Industry Procedural Guide – Control of Noise from Gasfield Activities" 2011[1]; and
- DERM "Assessment of Low Frequency Noise" Draft Guideline 2002.

The vibration criteria were based on the following standards:

- Australian Standard 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)"; and
- German Standard DIN 4150.3-1999 "Structural Vibration – Part 3: Effect of vibration on structures".

For blasting activity during construction, the appropriate noise and vibration criteria were established based on:

- the *Environment Protection Act 1994;* and
- the DERM "Noise and vibration from blasting" Guideline 2006.

[1] A document prepared by Ron Rumble Renzo Tonin, and released by DERM.

4.5 Noise Impact Assessment

As the sites and the equipment to be installed at the production facilities and production wells are yet to be finalised, the noise impact assessment has been based on a typical site layout and indicative equipment, with the site being located in an environment typical of the project development area.

The assessment considered the noise from the construction and operation each of the production facilities (each of the FCFs, CGPFs and IPFs) and productions wells. The production facilities and production wells considered were assumed to have the maximum production capacity (60TJ/d for the FCF, and 150 TJ/d for the CGPF and IPF), in order to provide a conservative (worst-case) assessment.

The noise from operation and construction of the production facilities and the production wells was modelled to several reference locations with various setback distances from the development site, which represents the possible locations of the closest sensitive receptors.

The noise impact assessment involves the following:

- establishing appropriate reference locations;
- determining the existing acoustic environment;
- determining the existing Arrow contribution;
- determining appropriate meteorological conditions for the noise modelling;
- identifying the typical equipment at the site;
- modelling the noise from the construction and operation of the site, and;
- determining the potential impact and appropriate mitigation measures.

4.6 Development of Noise Impact Assessment Procedure

The noise impact assessment conducted in this study has been based on typical layout and indicative equipment, with an assumed site location. It is noted that the site layout and equipment on site may change through the detailed design or front end engineering design process. As such, a noise impact assessment procedure has been developed to ensure that the noise from the facilities and production wells will achieve the established assessment criteria at sensitive receptors and will not adversely affect the environment.

The procedure includes:

- Site Selection;
- Determination of Existing Acoustic Environment;
- Determination of Existing Arrow Contribution;
- Determination of Resultant Criteria;
- Determination of Assessment Meteorological Conditions
- Equipment Selection;
- Noise Modelling for Construction and Operational Noise, and;
- Potential Impacts and Mitigation Measures for Construction and Operational Noise.

4.7 Vibration Impact Assessment

The assessment of vibration impacts of the project on sensitive receptors has been based on previous measurements of vibration levels at similar facilities with similar equipment and settings. The measured vibration levels were used to determine where there is potential for vibration impacts on sensitive receptors.

For the construction of the project, the exact nature of the construction techniques and equipment on site is not known at this stage. Therefore, the assessment of vibration impact at sensitive receptors has been based on general plant and equipment data, and supplemented with a proposal to conduct a monitoring regime at critical distances.

4.8 Blasting Impact Assessment

It is not anticipated that Arrow's construction activities will involve blasting however, the assessment considers appropriate provisions to be included in the construction management plan (such as the blast criteria and design factors) should the need arise.

4.9 Off-site Traffic Impact Assessment

The noise and vibration impact on sensitive receptors from off-site road traffic generated by the project has been considered based on the estimated project-traffic generation, determined in the road impact assessment, summarised in the Cardno Eppel Olsen "Surat Gas Impact Assessment Report – Road Impact Assessment" 2011 report.

4.10 Cumulative Impact Assessment

The cumulative noise and vibration impact of the project, existing developments, and projects with an approved EIS which are located in the Surat Basin region has been considered based on the modelled noise levels from the project, measured vibration levels at similar facilities and settings, and the likely location of appropriately designed coal seam gas industry (CSGI) related infrastructure in the region.

4.11 Analysis of the Potential Impact on Livestock

The potential noise and vibration impact on livestock in the vicinity of the project was determined based on outcomes of the noise and vibration impact assessments, and consideration of the current noise exposure of livestock.

5 EXISTING ENVIRONMENT AND ENVIRONMENTAL VALUES

5.1 Description of Existing Environmental Values

The EPP (Noise) includes the following provision relating to environmental values:

> *The environmental values to be enhanced or protected under this policy are –*
>
> *(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and*
>
> *(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following –*
>
> *(i) sleep;*
>
> *(ii) study or learn;*
>
> *(iii) be involved in recreation, including relaxation and conversation; and*
>
> *(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.*
>
> [Part 3, Clause 7]

5.2 Description of Existing Environment

The proposed project is located in rural area of Queensland's Surat Basin (refer Appendix A). The existing acoustic environment at most sensitive receptors within the basin is dominated by natural sounds such as wind in trees and birds. This results in a low noise environment, typical of a rural setting. In some areas, however, there are existing plant (such as production well and production facility equipment) associated with the CSGI which may have influence on the existing acoustic environment.

Background noise levels (L_{A90}) and ambient noise levels (L_{Aeq}) were measured at four different locations within the project development area. Measurements at three locations were made between the 21th and 29th of October 2009, and the other between the 7th and 13th of January 2010. The background noise levels were measured in accordance with the Queensland Department of Environment and Resource Management's (DERM) "Noise Measurement Manual". The approximate noise measurement locations are indicated on the diagram in Appendix B, with the coordinates shown in Table 5.1.

Table 5.1: Coordinates of background noise logging locations.

Measurement Location	Coordinates (GDA 94 MGA 56)		Measurement Period
	Easting	Northing	
ML 1	317259	6972259	21st – 29th October 2009
ML 2	319207	6947778	21st – 29th October 2009
ML 3	303932	6986083	21st – 29th October 2009
ML 4	310426	6969874	7th – 13th January 2010

Measurements at ML 2 and ML 3 were not influenced by noise from any existing production facilities or production wells. Background noise level measurements at these locations provide an overall indication of the existing background noise level at sensitive receptors within the project development area, which are not influenced by the existing CSGI.

ML 4 is situated at a sensitive receptor, approximately 3.8km from Tipton West Central Gas Processing Facility and approximately 800m to 1500m from existing production wells, while ML 1 is situated approximately 1700m to 2200m from existing productions wells. These locations provide an indication of the existing background noise level at sensitive receptors in proximity to existing production facilities and production wells.

The measured background and ambient noise levels at each measurement location are presented in Appendix C. Using this measured data, the Rating Background Levels (RBL) were calculated, in accordance with the “Planning for Noise Control” Guideline released by DERM. An RBL is the monitoring period median of the daily tenth percentiles of the measured background noise levels, for a given period (i.e., day, evening or night). The calculated RBLs are summarised in Table 5.2.

Table 5.2: Calculated Rating Background Levels.

Measurement Location	RBL (dB(A))		
	Day	Evening	Night
ML 1	26	29	26
ML 2	29	22	19
ML 3	25	22	19
ML 4	32	34	34

The calculated RBLs for ML 2 and ML 3 confirm that in general, the vast area of the Surat Basin presently experiences very low background noise levels, which are considered to be representative of all seasons.

The calculated RBLs for ML 1 are greater than those measured at ML 2 and ML 3 as the measured background noise levels had some influence from the existing production wells and other existing noise sources in the vicinity.

The calculated RBLs for ML 4 are significantly greater than those for the other three locations as the measured background noise levels at ML 4 were influenced by continuous noise predominantly from existing production wells with hydraulic wellheads. It is noted that the hydraulic wellheads are an older design, which produces significantly more noise than modern wellheads. It is not anticipated that Arrow will be using hydraulic wellheads as part of this project.

The influence of existing Arrow production wells and other facilities can be approximated during the periods where the background and ambient noise levels are similar. Based on measurements at ML 4, this occurs between 6pm on the 8th of January and 5am on the 9th of January (see Figure C.4, in Appendix C). At this time, the wind was from the east, representing close to worst-case meteorological conditions. Based on this period, it is estimated that the contribution of noise from the production wells and other facilities is approximately 40 dB(A) under worst-case meteorological conditions.

It is noted that during inspection of the four measurement locations, no appreciable vibration sources in the environment could be detected. The existing vibration levels are therefore considered to be below the threshold of human detection.

6 METEOROLOGICAL CONDITIONS AND ATMOSPHERIC EFFECTS

6.1 Weather Categories

The CONCAWE noise propagation model is widely accepted around the world as an appropriate model for predicting noise over significant distances. The model provides a meteorological category system to assist in accounting for the influence of meteorology on noise propagation.

The CONCAWE system divides the range of possible meteorological conditions into six separate "weather categories", from Category 1 to Category 6. Category 1 provides "best-case" (i.e. lowest noise level) weather conditions for the propagation of noise, whilst Category 6 provides "worst-case" (i.e. highest noise level) conditions, when considering wind speed, wind direction, time of day, and level of cloud cover. Category 4 provides "neutral" weather conditions for noise propagation.

For the purposes of comparison, Categories 1, 2 and 3 weather conditions are generally characterised by wind blowing from the receptor to the noise source during the daytime with little or no cloud cover. Category 4 conditions can be characterised by no wind and an overcast day, whilst no wind and a clear night sky with a temperature inversion (increasing temperature with elevation) represent Category 5 conditions. Category 6 conditions can be characterised by a clear night sky and wind blowing from the noise source to the receptor.

In the particular circumstances of this development, it is noted that the noise levels experienced at sensitive receptors in the vicinity of the production facilities and production wells will be significantly influenced by the weather category. For example, higher noise levels would be expected at sensitive receptors with a temperature inversion, or with wind blowing from the site to the sensitive receptor (i.e. Category 5 or 6 conditions) rather than with wind blowing from the sensitive receptor to the site (i.e. Category 1, 2, or 3 conditions).

6.2 Analysis of Meteorological Data

Twelve months of historical meteorological data measured within the project development area were processed to determine the likelihood of each meteorological category. The times during which the wind speed is greater than 5m/s have been listed separately and excluded from each category, as it is anticipated that ambient noise levels (from wind in trees) would mask the noise from the sites at these times. Table 6.1 summarises the percentage of time in each meteorological category for sensitive receptors located at different directions relative to the production facilities and production wells.

Table 6.1: Distribution of meteorological categories based on direction of sensitive receptors from a site.

Relative Direction from a Site	Percentage (%) of Time in each Meteorological Conditions Category													
	Wind speed > 5m/s		Category 1		Category 2		Category 3		Category 4		Category 5		Category 6	
	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time	Total	Night-time
North	18	6	1	0	9	4	26	34	18	20	19	22	10	15
Northeast	18	6	1	0	8	3	18	20	14	12	28	39	14	20
East	18	6	1	0	6	1	18	18	15	15	27	39	15	22
Southeast	18	6	1	0	5	2	15	15	16	14	33	45	12	18
South	18	6	1	0	9	7	17	16	18	19	27	39	10	12
Southwest	18	6	1	0	13	7	26	34	14	19	19	25	8	9
West	18	6	2	0	13	8	24	33	19	25	20	23	5	5
Northwest	18	6	2	0	10	6	30	39	18	22	18	21	5	6

Note: Total refers to the total percentage of time in each category.
Night-time refers to the percentage of time in each category during night-time only.

6.3 Meteorological Conditions for Noise Modelling

For compliance testing, the DERM “Noise Measurement Manual” requires that the noise measurement be conducted during fine weather conditions with calm to light winds. Measurements during conditions conducive to sound propagation should only be conducted if the conditions are a true representation of the normal situation in the area. Therefore, for noise modelling, it is appropriate that the occurrence of weather conditions conducive to sound propagation be considered.

The meteorological conditions conducive to sound propagation (Categories 5 and 6) are considered to be a significant feature of the area if there is at least a total of 30% occurrence of these conditions in any assessment period. Based on Table 6.1, Categories 5 and 6 weather conditions are considered to be a feature of the project development area for sensitive receptors located in all directions, except for those to the west and northwest of a site.

For the purpose of this assessment, the worst-case meteorological conditions (Category 6) have been applied.

7 CRITERIA

Given the form of development of the Surat Gas Project, the DERM released "Coal Seam Gas Industry Procedural Guide – Control of Noise from Gasfield Activities" has been used as the primary method of objectively assessing the noise from the project. However, reference is also made to the EPP (Noise), World Health Organisation (WHO) Guidelines, and the DERM "Assessment of Low Frequency Noise" Draft Guideline.

Different noise criteria are proposed for the different classes of activities associated with the project, being short-term, medium-term and long-term activities. These classes of activities relate to the construction and operation of the production facilities (i.e., FCFs, CGPFs, and IPFs), production wells, and associated pipelines (water and gas pipelines between production wells and processing facilities).

In order to objectively assess the impact of vibration, reference is made to the Australian Standard 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)" and the German Standard DIN 4150.3-1999 "Structural Vibration – Part 3: Effect of vibration on structures".

For blasting activity conducted during construction, separate noise and vibration criteria are proposed. To determine the appropriate criteria, reference is made to the *Environmental Protection Act 1994* and the DERM "Noise and vibration from blasting" Guideline.

7.1 Noise

7.1.1 Coal Seam Gas Industry Procedural Guide

The Coal Seam Gas Industry Procedural Guide – Control of Noise from Gasfield Activities (the Procedural Guide) has been developed with the aim to assist authorities with the regulation of noise emission from the CSGI in Queensland, and deals specifically with environmental noise from gasfield activities.

The objectives of the Procedural Guide include the recommendation for noise emission criteria, which comply with the objectives of the EPP (Noise). DERM has previously used the Procedural Guide to specify appropriate noise conditions for similar CSGI projects in the region, and therefore is considered appropriate for this project.

The Procedural Guide recommends noise emission criteria for three different classes of activities, short-term, medium-term and long-term, as defined in Table 7.1. The recommended noise emission criteria are based on the measured long-term average background noise levels or the minimum deemed background noise levels (as provided in Table 7.2); and are determined in accordance with Table 7.3.

Table 7.1: Classes of activity.

Activity/Noise Event	Description of Noise Exposure at Sensitive Receptors
Short-term	Noise exposure which persists for an aggregate period not greater than eight hours and does not re-occur (for a period of one hour or more) for a period of at least seven days.
Medium-term	Noise exposure which persists for an aggregate period not greater than five days and does not re-occur (for a period of one hour or more) for a period of at least four weeks.
Long-term	Noise exposure which persists for a period greater than five days even when there are respite periods when the noise is inaudible within those five days.

Table 7.2: Minimum deemed background noise levels.

Time Period	Deemed Background Noise Levels
7:00am – 6.00pm	35 dB(A)
6:00pm – 10:00pm	30 dB(A)
10:00pm – 6:00am	25 dB(A)
6:00am – 7:00am	30 dB(A)

Table 7.3: Noise criteria at sensitive receptors.

Time Period	Short-term Noise Event	Medium-term Noise Event	Long-term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}\ L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}\ L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) $_{max}\ L_{p,A,15mins} \leq$ 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)

Note: L_{Aeq} is to be measured over any 15 minute period.
$_{adj}$ to be applied subjectively according to the EPA Noise Measurement Manual.
$_{max}L_A$ is the maximum level measured over any 15 minute period at night.

Where the measured background noise levels are below the minimum deemed background noise levels, the recommended noise criteria in accordance with the Procedural Guide will be based on the minimum deemed background noise levels. Therefore, the most stringent noise criteria at sensitive receptors are summarised in Tables 7.4.

Table 7.4: Noise criteria at sensitive receptors.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

Considering that the exact infrastructure locations within the project development area have not been finalised at this stage of the development, site specifics such as the location of the closest sensitive receptor and the existing acoustic environment could not be accurately determined. Consequently, site-specific resultant noise criteria at potentially affected sensitive receptors could not be determined.

Therefore for this assessment, it has been assumed that all potentially affected sensitive receptors will predominantly have a low noise environment with no noise contribution from existing CSGI plant. This assumption is representative of most sensitive receptors within the project development area. Based on this assumption, the resultant noise criteria at sensitive receptors in accordance with the Procedural Guide are those provided in Table 7.4.

Notwithstanding the above, where the existing background noise levels at sensitive receptors are likely to be greater than the minimum deemed background noise levels (as provided in Table 7.2) and do not have influence from any existing CSGI plant, background noise logging may be conducted which may result in less stringent criteria.

It is noted that the noise criteria provided by the Procedural Guide (such as those shown in Table 7.4) will be applied for both the operation and construction of the project. The criteria applied for construction noise associated with this project are significantly more stringent than those that would typically be required by DERM for general construction works.

7.1.2 Environment Protection (Noise) Policy 2008

The Environmental Protection (Noise) Policy 2008 (the Policy) provides the management intent of controlling background noise creep, as well as achieving acoustic quality objectives for sensitive receptors.

A traditional approach to environmental noise has been to measure existing background noise levels prior to a development and to set environmental noise criteria at a certain level above the existing background noise level. Where this methodology is used, background noise levels are measured over a period of time to incorporate a range of meteorological conditions. The background noise level used is at the lower end of the range of measured levels.

One of the concerns about this methodology is that each development may increase the background noise level allowing more relaxed criteria for future developments. This theoretical phenomenon of the degradation of the acoustic environment with successive developments is known as background creep. For this development to contribute to background creep, successive developments would need to rely on background noise levels, which have been elevated by previous projects, to set less stringent criteria.

Since the development of the WHO Guidelines (refer Section 6.1.3), it has become more common for regulatory authorities to base environmental noise criteria on avoiding health and wellbeing impacts rather than comparison with background noise levels. The EPP (Noise) includes acoustic quality objectives based on the WHO Guidelines. These are described in Table 6.5.

Table 7.5: **The EPP (Noise) acoustic quality objectives.**

Sensitive Receptor	**Time of Day**	**Acoustic Quality Objectives (dB(A)) at Sensitive Receptor**			**Environmental Value**
		$L_{Aeq,adj,1hr}$	$L_{A10,adj,1hr}$	$L_{A1,adj,1hr}$	
dwelling (for outdoors)	daytime[1] and evening[2]	50	55	65	health and wellbeing
dwelling (for indoors[4])	daytime and evening	35	40	45	health and wellbeing
	night-time[3]	30	35	40	health and wellbeing in relation to the ability to sleep

Note:
[1] Daytime is defined by the Policy as "the period after 7am on a day to 6pm on the day".
[2] Evening is defined by the Policy as "the period after 6pm on a day to 10pm on the day".
[3] Night-time is defined by the Policy as "the period after 10pm on a day to 7am on the next day".
[4] In accordance with the WHO Guidelines, indoor noise levels can be converted to outdoor levels by the addition of 15 dB(A) assuming windows being partially open for ventilation.

It is noted that the Procedural Guide recommends noise criteria which comply with the objectives of the EPP (Noise).

7.1.3 World Health Organisation Guidelines

The WHO has developed guidelines[2] for community noise in specific environments. With respect to annoyance, the guidelines state:

> *To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB L_{Aeq} for a steady continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB(A) L_{Aeq}.*
>
> [Section 4.3.1, Page 61]

To avoid sleep disturbance, the WHO suggests that the equivalent noise level (L_{Aeq}) should be limited to 30 dB(A) inside a bedroom at night. Based on the windows being partially open, the WHO suggests that to achieve the internal level described above, the equivalent noise level outside a bedroom window should be limited to 45 dB(A).

Sonus has recently conducted tests of the noise reduction achieved across the facade of a number of dwellings. These tests include a range of facade constructions from light weight transportable homes to masonry homes. The results of the testing indicate that with windows partially open for ventilation, the noise transfer is typically around 15 dB(A). The tests confirms that the WHO noise reduction of 15 dB(A) across a facade is appropriate.

It is noted that The enHealth Council's "The Health Effects of Environmental Noise – Other Than Hearing Loss" 2004 report recommends that the WHO guidelines be referenced for appropriate environmental noise levels, below which no health effects will be expected.

7.1.4 Low Frequency Noise Draft Guideline.

In recent times, there has been an escalation of low frequency noise complaints experienced by residents in Queensland due to new industrial development (Roberts, 2004). To ensure the low frequency noise from the operation of the project does not have a significant impact on the sensitive receptors, reference has been made to the DERM "Assessment of Low Frequency Noise" Draft Guideline.

The draft guideline separates the assessment of low frequency noise based on the frequency content of the noise and whether the noise is tonal or broad band. Based on measurements

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[2] Berglund, Lindvall and Schwela, 1999, "Guidelines for Community Noise".

of similar equipment at other similar facilities, the noise experienced at sensitive receptors will not include a significant component of infrasound (less than 20Hz) and will not be tonal.

For non-tonal, low frequency noise in the range of 20Hz to 200Hz, the draft guideline suggests that the noise is considered to be acceptable if the contribution of low frequency noise within a sensitive receptor dwelling ($L_{pA,LF}$) does not exceed 20 dB(A) during the evening or night and 25 dB(A) during the day.

The low frequency noise transfer from outside to inside sensitive receptor dwellings varies significantly based on the construction of the dwelling. Sonus has conducted tests of the noise reduction achieved across the facade of a number of dwellings. The results from these tests indicate that the low frequency noise reduction, with windows partially open, ranges from 10 dB(A) for a light weight transportable home to 20 dB(A) for a well constructed masonry home. This assessment has been based on a noise reduction of 10 dB(A), which represents a worst-case (conservative) assessment.

7.1.5 Proposed Noise Conditions

Based on the policy and guidelines described above, appropriate noise conditions for the different activities of the project have been proposed, depending on the existing acoustic environment (referred to as scenarios) at sensitive receptors. The activities considered are summarised in Table 7.6.

Table 7.6: Operation and construction activity.

Noise Exposure	Activity/Event
Short term	Flaring.
Medium term	Drilling of production wells. Completion and Workover activities.
Long term	Site preparation and completion - construction of the production facilities, production wells and pipelines (gas and water). Operation of the production facilities and production wells. Abandonment of production wells.

The proposed noise conditions are as follows:

- **Scenario 1** – for sensitive receptors with a low noise environment, the proposed noise conditions are summarised in Table 7.7
- **Scenario 2** – for sensitive receptors with background noise levels which are greater than the minimum deemed background noise levels of the Procedural Guide, and have no influence from an existing Arrow plant, the proposed noise conditions are derived in accordance with Table 7.8, which will be based on additional background noise monitoring; and,
- **Scenario 3** – for sensitive receptors with noise influence from an existing Arrow plant, the proposed noise conditions are summarised in Table 7.9.

Table 7.7: Proposed noise conditions at sensitive receptors – Scenario 1.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

Table 7.8: Proposed noise conditions at sensitive receptors – Scenario 2.

Time Period	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)

Table 7.9: Proposed noise conditions at sensitive receptors – Scenario 3.

Time Period	Noise Criteria
All periods	Total noise level (new and existing Arrow plant) no greater than the existing Arrow plant noise contribution.

7.2 Vibration

There are two potential components of vibration impacts associated with the project, which relate to human comfort and structural damage. For operation of the project, both components relating to human comfort and structural damage are considered, while for the construction of the project, the structural damage aspect of vibration is considered.

The criteria for human comfort are more stringent than the criteria which apply to the potential structural damage of buildings. The Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999 provide appropriate criteria to objectively assess these impacts of vibration from the project.

7.2.1 Australian Standard AS 2670.2-1990

The Australian Standard AS 2670.2-1990 provides the magnitudes of vibration that approximate human perception. To ensure human comfort and prevent complaints due to annoyance, the measured vibration at the sensitive receptors should be less than the vibration levels provided by AS 2670.2, as shown in Table 7.10.

7.2.2 German Standard DIN 4150.3-1999

The German Standard DIN 4150.3-1999 provides short-term and long-term acceptable vibration levels to ensure structural integrity of various building types. For dwellings, the short-term acceptable vibration levels are provided in Table 7.11, while the long-term acceptable vibration level is provided in Table 7.12.

The short-term vibration levels are used to assess the impacts of vibration during the construction works while the long-term vibration levels are used to assess the impact of vibration during project operation.

Table 7.10: Operational vibration criteria for human comfort.

1/3 Octave Band Frequency (Hz)	Acceleration (r.m.s) m/s^2		
	z-axis	x,y-axis	Sum
1	1×10^{-2}	3.6×10^{-3}	3.6×10^{-3}
1.25	8.9×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
1.6	8×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
2	7×10^{-3}	3.6×10^{-3}	3.6×10^{-3}
2.5	6.3×10^{-3}	4.51×10^{-3}	3.72×10^{-3}
3.15	5.7×10^{-3}	5.68×10^{-3}	3.87×10^{-3}
4	5×10^{-3}	7.21×10^{-3}	4.07×10^{-3}
5	5×10^{-3}	9.02×10^{-3}	4.3×10^{-3}
6.3	5×10^{-3}	1.14×10^{-2}	4.6×10^{-3}
8	5×10^{-3}	1.44×10^{-2}	5×10^{-3}
10	6.3×10^{-3}	1.8×10^{-2}	6.3×10^{-3}
12.5	7.81×10^{-3}	2.25×10^{-2}	7.8×10^{-3}
16	1×10^{-2}	2.89×10^{-2}	1×10^{-2}
20	1.25×10^{-2}	3.61×10^{-2}	1.25×10^{-2}
25	1.56×10^{-2}	4.51×10^{-2}	1.56×10^{-2}
31.5	1.97×10^{-2}	5.68×10^{-2}	1.97×10^{-2}
40	2.5×10^{-2}	7.21×10^{-2}	2.5×10^{-2}
50	3.13×10^{-2}	9.02×10^{-2}	3.13×10^{-2}
63	3.94×10^{-2}	1.14×10^{-1}	3.94×10^{-2}
80	5×10^{-2}	1.44×10^{-1}	5×10^{-2}

Note: x-axis = back to chest
y-axis = right side to left side
z-axis = foot (or buttocks) to head

Table 7.11: Short-term construction vibration criteria for the prevention of structural damage.

Vibration Level (mm/s)			
At the foundation of the Dwelling			At Horizontal Plane of Highest Floor of Dwelling
1 to 10 Hz	10 to 50 Hz	Above 50 Hz	
5	5 to 15	15 to 20	15

Table 7.12: Long-term operational vibration criteria for the prevention of structural damage.

Location	Vibration Level (mm/s) at All Frequencies
Horizontal plane of the highest floor of dwelling	5

7.3 Blasting

It is noted that blasting is not anticipated during construction of the project however, the assessment considers appropriate criteria should the need arise.

The *Environmental Protection Act 1994* has specifically included a section for blasting activity, which provides allowable noise and vibration levels from the activity. This assessment has therefore considered separate noise and vibration criteria for blasting activity which has been based on the *Environmental Protection Act 1994,* with consideration given to the DERM "Noise and vibration from blasting" Guideline.

7.3.1 Environment Protection Act 1994

The *Environmental Protection Act 1994* includes the following provision in relation to blasting activity:

> ***440ZB Blasting***
>
> *A person must not conduct blasting if –*
>
> *(a) the airblast overpressure is more than 115dB Z Peak for 4 out of any 5 consecutive blasts; or*
>
> *(b) the airblast overpressure is more than 120dB Z Peak for any blast; or*
>
> *(c) the ground vibration is –*
>
> *(i) for vibrations of more than 35Hz – more than 25mm a second ground vibration, peak particle velocity; or*
>
> *(ii) for vibrations of no more than 35Hz – more than 10mm a second ground vibration, peak particle velocity.*
>
> [Division 3, Page 416]

7.3.2 Noise and Vibration from Blasting Guideline

The DERM "Noise and vibration from blasting" Guideline includes the following provisions:

> ***Noise Criteria***
>
> *Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise sensitive place, then*
>
> *(a) the airblast overpressure must be not more than 115dB(linear) peak for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and*

(b) the airblast overpressure must not exceed 120dB(linear) peak for any blast.

Vibration Criteria

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a noise-sensitive place:

(a) the ground-borne vibration must not exceed a peak velocity of 5mm per second for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and

(b) *the ground-borne vibration must not exceed a peak particle velocity of 10mm per second for any blast.*

[Procedure Section, Page 1]

8 NOISE IMPACT ASSESSMENT

At this stage of the development, the site location and design of the production facilities and production wells are yet to be finalised. In the absence of exact information of the sites, the noise impact assessment has been based on example locations, with typical site layout and indicative equipment.

The assessment considered the construction and operation of each type of the production facility (the FCFs, CGPFs and IPFs), and the production wells.

8.1 Production Facilities

8.1.1 Reference Locations

As the exact site locations of the facilities are yet to be finalised at this stage, the location of sensitive receptors in the vicinity of the facility could not be determined. However, it is understood that a site selection procedure will be implemented to determine the actual facility location and that typically, the distance of the facility from a sensitive receptor will be maximised as much as practicable.

For the purpose of this assessment, random positions with various distances from a facility have been considered, which are representative of the potential closest sensitive receptor to the facility. These random positions are referred to as reference locations (RFs) and are summarised in Table 8.1. The relative direction of the reference locations has been based on the facility orientation as indicated on the conceptual layout in Appendix D. The model separation distance of the reference locations from the site is taken from the centre of the facility, also indicated on the conceptual layout in Appendix D

Table 8.1: Reference locations of the potential closest sensitive receptor.

Reference Location	Relative Direction from Facility	Distance from Facility (km)
RF 1	West	1
RF 2	West	2
RF 3	West	3
RF 4	West	5
RF 5	South	1
RF 6	South	2
RF 7	South	3
RF 8	South	5

8.1.2 Existing Acoustic Environment

For the purpose of this assessment, an existing low noise environment was assumed at the locations of potential closest sensitive receptors to the sites (i.e., reference locations). This assumption will most likely be valid for most sites, based on background noise monitoring previously conducted within the Surat Basin.

8.1.3 Existing Arrow Contribution

For most sites, there will be no existing Arrow facilities in the vicinity, which may influence the noise at the sensitive receptors in the vicinity of the new site. Therefore, for the purpose of this assessment and considering a typical situation, it is assumed that there is no noise contribution from existing Arrow facilities at the site.

It is noted that if there is noise contribution from existing Arrow facility, the noise from the existing facility will be taken into account in the modelled noise level at sensitive receptors. Following this appropriate noise criteria will be applied to ensure the cumulative noise from new and existing facilities does not have a significant noise impact on sensitive receptors.

8.1.4 Resultant Criteria

For an existing low noise environment as determined in Section 8.1.2, the resultant noise criteria at all reference locations are provided in Table 8.2. These criteria are the most stringent in accordance with the Procedural Guide.

Table 8.2: Noise criteria at sensitive receptors.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

It is noted that the noise criteria above are applied for both the operation and construction of the facilities. The criteria applied for construction noise are significantly more stringent than those that would typically be required by DERM for general construction work.

8.1.5 Meteorological Conditions for Noise Modelling

For the reference locations situated to the south of a site (RF 5 to RF 8), the appropriate assessment conditions are the worst-case (Category 6) meteorological conditions, while for the reference locations situated to the west (RF 1 to RF 4), the neutral (Category 4) meteorological conditions are considered appropriate.

For the purpose of this assessment, the worst-case (Category 6) meteorological conditions have been considered in the assessment of noise at all reference locations. This will provide a conservative assessment of the noise at the reference locations to the west.

8.1.6 Typical Facility Equipment

The final selection of the make of equipment and configuration at the production facilities is yet to be determined at this stage of development, however indicative equipment has been considered. The main noise sources for the different components of the proposed FCFs, CGPFs and IPFs considered in this assessment are provided in Table 8.3. The equipment at each facility have been based on the configuration for the largest production capacity for each facility type, which are as follows:

- 60 TJ/d for the FCF;
- 150 TJ/d for the CGPFs and IPFs.

Table 8.3 also contains sound power levels and the quantity of each type of equipment proposed at each facility type. The octave band sound power levels for all of the equipment considered are provided in Table E.1, in Appendix E.

Table 8.3: Main noise sources at the production facility.

Noise Source	Total Sound Power Level (dB(A))	Quantity at each Facility		
		FCF – 60TJ/d	CGPF – 150TJ/d	IPF – 150TJ/d
Long Term Noise Sources				
First Stage Gas Compression Unit				
Screw compressor	**113**	6	15	15
Electric motor - 2000hp	**105**	6	15	15
Cooler (2 fans, inlet plus outlet)	**106**	6	15	15
Further Stages Gas Compression Unit				
Reciprocating compressor	**120**	2	6	10
Electric motor - 5500hp	**108**	2	6	10
Cooler (3 fans, inlet plus outlet)	**109**	2	6	10
Power Generation Plant				
Power generator - 3.5 kW	**87**	5	14	16
Gas engine - exhaust with manufacturer installed silencer	**84**	5	14	16
Gas engine - air intake	**101**	5	14	16

Table 8.3.: Main noise sources at the production facility (continued).

Noise Source	Total Sound Power Level (dB(A))	Quantity at each Facility		
		FCF – 60TJ/d	CGPF – 150TJ/d	IPF – 150TJ/d
Long Term Noise Sources				
Water Treatment Facility				
Centrifugal pump	**87**	N/A	N/A	44
Electric motor - 55 kW	**87**	N/A	N/A	30
Electric motor - 450 kW	**95**	N/A	N/A	14
Water Transfer Pump				
Centrifugal pump – 150 kW	**98**	N/A	1	1
Flare				
Normal operation (pilot flame) – 0.02 TJ/d	**93**	1	1	1
Short Term Noise Sources				
Flare				
Maximum flow – 60TJ/d	**107**	1	N/A	N/A
Maximum flow – 150TJ/d	**110**	N/A	1	1

8.1.7 Noise Modelling

The noise from the construction and operation of the production facilities has been modelled for the reference locations using the CONCAWE noise propagation model in the SoundPlan noise modelling software. Flat ground topography has been assumed in the model given the generally flat ground in the project development area. Considering the typical ground surface cover of the Surat Basin, the ground of the project development area has been modelled as being covered with grass or rough pasture.

Construction Noise

As the nature of construction techniques, processes and equipment for the production facilities will be determined through the design phase (e.g., front end engineering design phase) by final equipment selections and site-specific requirements (e.g., earth works requirements), exact details regarding the noise sources that will be used during the construction phase are not currently available.

In these circumstances, noise levels from construction of the proposed facilities have been modelled based upon typical construction equipment that may be used at the site. The sound power levels for construction equipment have been based on the Australian Standard AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites, as well as manufacturer's data and Sonus' database of noise sources. Table 8.4 details the equipment and overall sound power levels included in this assessment.

Table 8.4: Main noise sources during the construction of the production facilities.

Main Noise Source	Maximum Overall Sound Power Level (dB(A))
Truck	120
Front end loader	118
Excavator	118
Dozer	120
Grader	118
Scraper	116
Crane	115
Generator	119
Welding generator	113
Air compressor	107
Hand-held grinder	106

For the construction of each production facility (i.e., FCF, CGPF and IPF), the same equipment and construction activity has been considered. The construction of the facilities has been considered in three stages, with the equipment or processes during each stage summarised in Table 8.5.

Table 8.5: Equipment or process during the construction stages of the production facilities considered.

Construction Stage	Equipment or Processes
Site preparation	Truck Front end loader Excavator Scraper Dozer Grader
Surface equipment installation	Truck Crane Hand-held grinder Generator Welding Generator Air Compressor
Site rehabilitation	Grader Bobcat

Based upon the above equipment and sound power levels, modelling of the noise at the reference locations from construction of the production facilities has been made under worst-case meteorological conditions. The modelling assumes a "worst-case" period for each stage of all equipment operating simultaneously and continuously within the respective construction site area. The modelled noise levels are provided in Table 8.6.

Table 8.6: Modelled noise levels from the construction of the production facilities.

Construction Stage	Equipment or Processes	Modelled Noise Level, dB(A)							
		RF 1	RF 2	RF 3	RF 4	RF 5	RF 6	RF 7	RF 8
Site preparation	Truck	42	31	23	14	41	31	24	14
	Front end loader	41	32	26	17	41	32	26	18
	Excavator	42	32	25	15	43	33	26	16
	Scraper	40	31	25	15	41	32	25	16
	Dozer	44	35	28	19	42	34	28	19
	Grader	42	33	27	17	43	34	27	18
	Total	**50**	**41**	**34**	**25**	**50**	**41**	**35**	**25**
Surface equipment installation	Truck	42	31	23	14	41	31	24	14
	Crane	39	30	24	14	40	31	24	15
	Hand-held grinder	27	16	<10	<10	29	18	11	<10
	Generator	43	34	27	18	43	34	27	18
	Welding Generator	37	28	21	12	37	28	22	12
	Air Compressor	31	22	16	<10	33	23	17	<10
	Total	**47**	**37**	**31**	**21**	**47**	**38**	**31**	**22**
Site rehabilitation	Truck	42	31	23	14	41	31	24	14
	Front end loader	41	32	26	17	41	32	26	18
	Excavator	42	32	25	15	43	33	26	16
	Grader	42	33	27	17	43	34	27	18
	Total	**48**	**38**	**32**	**22**	**48**	**39**	**32**	**23**

The modelling indicates that the noise at all reference locations during the different stages of construction of the production facilities will achieve the established long term noise criteria for certain periods of the day, except at RF 1, RF2, RF 5 and RF 6. The modelled noise levels at RF 1, RF2, RF 5 and RF 6 do not achieve the daytime long term noise criterion of 40 dB(A) under worst-case meteorological conditions. Mitigation measures to reduce the noise impact at sensitive receptors from the construction the production facilities are provided in Section 8.1.8.

Operational Noise

The noise from the operation of the production facilities has been modelled under worst-case meteorological conditions (Category 6), and has been based on sound power levels of the main noise sources as provided in Table 8.3. The arrangement of equipment at each facility has been based on the conceptual layout as provided in Appendix D.

Long Term Noise Sources

The modelled noise levels at the reference locations from long-term noise sources at the production facilities are provided in Table 8.7. A noise contour of the modelled noise levels of the 150 TJ/d IPF (i.e., facility with the most noise sources), is provided in Appendix F.

Table 8.7: Modelled noise levels at reference locations from long term noise sources at the production facilities.

Reference Location	Distance (km) from Centre of Facility	Noise Criterion (dB(A))	Modelled Noise Level (dB(A)) from the Production Facility		
			FCF	CGPF	IPF
RF 1	1	28	48	52	53
RF 2	2	28	37	41	43
RF 3	3	28	30	34	36
RF 4	5	28	20	24	26
RF 5	1	28	49	54	55
RF 6	2	28	38	42	44
RF 7	3	28	31	35	37
RF 8	5	28	21	25	27

The modelling indicates that the noise at all reference locations exceeds the noise criterion of 28 dB(A) (i.e., the night-time limit for long-term noise events) under worst-case meteorological conditions for all facility types, except at RF 4 and RF 8, which are located approximately 5km from the sites. In order to achieve the criterion at reference locations within 3km of the facilities, mitigation measures will need to be incorporated, which are considered in Section 8.1.8.

Short Term Noise Sources

The modelled noise level at the reference locations from the short-term noise source at the production facilities, mainly being the gas flaring, is provided in Table 8.8. Although the flaring will be intermittent, the exact length of time of the flaring process is not known at this stage of the development. Therefore, the model assumes continuous flaring over the 15 minute assessment period. The assessment criterion for flaring has been based on the noise limit for short-term noise events, given the flaring will likely to occur for a period of less than eight hours.

Table 8.8: Modelled noise levels at reference locations from short-term noise sources at the production facilities.

Noise Source	Modelled Noise Level, dB(A)							
	RF 1	RF 2	RF 3	RF 4	RF 5	RF 6	RF 7	RF 8
FCF maximum flow flare – 60 TJ/d	29	19	12	<10	34	21	14	<10
CGPF and IPF maximum flow flare – 150 TJ/d	32	22	15	<10	37	24	17	<10

Based on the modelled noise levels, the noise from gas flaring will exceed the short term night-time criterion of 28 dB(A) at RF 1 and RF 5 (both located 1km from a facility), but will achieve the short-term criterion for other periods of the day. The modelled noise level at other reference locations easily achieves the short-term criteria.

8.1.8 Mitigation Measures

Where the modelled noise level from construction and operation of the production facilities exceeds the established assessment criteria at sensitive receptors, additional acoustic treatment and mitigation measures have been considered.

Construction Noise

The modelling of construction noise assumes the "worst-case" scenario where all identified noise sources are operating continuously and simultaneously.

In practice, it is unlikely that all equipment will operate continuously and simultaneously. Specific mitigation measures will be confirmed once the actual construction processes are known and modelling or measurements have been conducted.

In certain circumstances, the established criteria may not be able to be achieved due to the nature of the construction activity. Where there is the potential for such an event to occur, community liaison and communication will be conducted.

In all cases, all reasonable and practicable mitigation measures will be implemented in order to reduce the noise impact at sensitive receptors. These include the following:

- Ensuring noise reduction devices such as mufflers are fitted and operate effectively;
- Ensuring machinery or equipment is not operated if maintenance or repairs would eliminate or significantly reduce a characteristic of noise from its operation that is audible at the nearest residences;
- Locating noise making equipment or processes such that their impact on the closest sensitive receptor is minimised. This will be achieved by maximising the distance to the closest sensitive receptor, or using structures or elevations to create barriers;
- Operating equipment and handling material so as to minimise impact noise;
- Shutting or throttling down equipment when not in actual use;
- Using off-site or other alternative processes that eliminate or lessen resulting noise
- Commencing any particular noisy part of the work after 9.00am.

- Where practicable, restricting noisy construction work or equipment to the hours of 7am to 6pm.

Operational Noise

Where the modelled noise from the operation of the facilities exceeds the established noise criteria, mitigation measures in the form of conceptual acoustic treatment to be developed during the design stage of the project have been considered. The acoustic treatment that has been considered is summarised in Table 8.9.

Table 8.9: Feasible acoustic treatment packages.

Treatment	Potential Treatment
Enclosure Treatment Package 1	Sealed steel enclosure with 1mm sheet thickness, and single stage acoustic louvres at inlet and discharge.
Enclosure Treatment Package 2	Sealed steel enclosure with1mm sheet thickness, and two stage (600mm) acoustic louvres at inlet and discharge.
Enclosure Treatment Package 3	Sealed steel enclosure with 1mm sheet thickness having 50mm sound absorbing internal lining, and 900mm long (33%) splitter attenuators at inlet and discharge.
Enclosure Treatment Package 4	Sealed steel enclosure with 1.6mm sheet thickness having 75mm sound absorbing internal lining, and 1500mm long (33%) splitter attenuators at inlet and discharge.
Cooler Treatment Package 1	Medium-grade cooler silencers
Cooler Treatment Package 2	High-grade cooler silencers
Cooler Treatment Package 3	Fan with Variable Fan Drive (VFD), and high-grade cooler silencers
Cooler Treatment Package 4	Ultra low noise fan with VFD, and high-grade cooler silencers
Muffler	Low-grade, medium-grade or high-grade mufflers

Mitigation Measures for Long Term Noise Sources

In order to achieve the long term night-time noise criterion of 28 dB(A), additional acoustic treatment will be required to be incorporated into the design of each of the facilities. The acoustic treatment, summarised in Table 8.9, has been considered for the main noise sources in order to achieve the criterion at reference locations located 1km (RF 1 and RF 5), 2km (RF 2 and RF 6) and 3km (RF 3 and RF 7) away from the facilities. The potential treatment and the achievable noise level reduction with the application of the treatment to the main noise sources are provided in Tables 8.10 to 8.12.

Table 8.10: Attenuation from acoustic treatment for FCFs.

Noise Source	Noise Level Reduction (dB)							Potential Treatment
	63	125	250	500	1000	2000	4000	
Attenuation to achieve 28 dB(A) at 1km from an FCF (i.e. at RF 1 or RF 5)								
First Stage Gas Compression Unit								
Screw compressor	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Electric motor - 2000hp	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Cooler (2 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Further Stages Gas Compression Unit								
Reciprocating compressor	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Electric motor - 5500hp	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Cooler (3 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Power Generation Plant								
Gas engine - air intake	0	5	10	15	20	15	10	High-grade muffler
Attenuation to achieve 28 dB(A) at 2km from an FCF (i.e. at RF 2 or RF 6)								
First Stage Gas Compression Unit								
Screw compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 2000hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (2 fans, inlet plus outlet)	2	8	10	16	14	10	0	Cooler Treatment Package 2
Further Stages Gas Compression Unit								
Reciprocating compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 5500hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (3 fans, inlet plus outlet)	0	1	3	8	6	3	0	Cooler Treatment Package 1
Attenuation to achieve 28 dB(A) at 3km from an FCF (i.e. at RF 3 or RF 7)								
First Stage Gas Compression Unit								
Cooler (2 fans, inlet plus outlet)	0	1	3	8	6	3	0	Cooler Treatment Package 1
Further Stages Gas Compression Unit								
Reciprocating compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 5500hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (3 fans, inlet plus outlet)	0	1	3	8	6	3	0	Cooler Treatment Package 1

Table 8.11: Attenuation from acoustic treatment for CGPFs.

Noise Source	Noise Level Reduction (dB)							Potential Treatment
	63	125	250	500	1000	2000	4000	
Attenuation to achieve 28 dB(A) at 1km from a CGPF (i.e. at RF 1 or RF 5)								
First Stage Gas Compression Unit								
Screw compressor	5	10	21	39	46	41	18	Enclosure Treatment Package 3
Electric motor - 2000hp	5	10	21	39	46	41	18	Enclosure Treatment Package 3
Cooler (2 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Further Stages Gas Compression Unit								
Reciprocating compressor	5	11	27	42	46	41	19	Enclosure Treatment Package 4
Electric motor - 5500hp	5	11	27	42	46	41	19	Enclosure Treatment Package 4
Cooler (3 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Power Generation Plant								
Power generator - 3.5 kW	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Gas engine - air intake	0	5	10	15	20	15	10	High-grade muffler
Attenuation to achieve 28 dB(A) at 2km from a CGPF (i.e. at RF 2 or RF 6)								
First Stage Gas Compression Unit								
Screw compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 2000hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (2 fans, inlet plus outlet)	2	8	10	16	14	10	0	Cooler Treatment Package 2
Further Stages Gas Compression Unit								
Reciprocating compressor	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Electric motor - 5500hp	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Cooler (3 fans, inlet plus outlet)	2	8	10	16	14	10	0	Cooler Treatment Package 2
Power Generation Plant								
Gas engine - air intake	0	0	0	2	5	2	0	Low-grade muffler
Attenuation to achieve 28 dB(A) at 3km from a CGPF (i.e. at RF 3 or RF 7)								
First Stage Gas Compression Unit								
Screw compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 2000hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (2 fans, inlet plus outlet)	0	1	3	8	6	3	0	Cooler Treatment Package 1
Further Stages Gas Compression Unit								
Reciprocating compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 5500hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (3 fans, inlet plus outlet)	0	1	3	8	6	3	0	Cooler Treatment Package 1

Table 8.12: Attenuation from acoustic treatment for IPFs.

Noise Source	Noise Level Reduction (dB)							Potential Treatment
	63	125	250	500	1000	2000	4000	
Attenuation to achieve 28 dB(A) at 1km from an IPF (i.e. at RF 1 or RF 5)								
First Stage Gas Compression Unit								
Screw compressor	5	10	21	39	46	41	18	Enclosure Treatment Package 3
Electric motor - 2000hp	5	10	21	39	46	41	18	Enclosure Treatment Package 3
Cooler (2 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Further Stages Gas Compression Unit								
Reciprocating compressor	5	11	27	42	46	41	19	Enclosure Treatment Package 4
Electric motor - 5500hp	5	11	27	42	46	41	19	Enclosure Treatment Package 4
Cooler (3 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4
Power Generation Plant								
Power generator - 3.5 kW	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Gas engine - air intake	0	5	10	15	20	15	10	High-grade muffler
Water Treatment Facility								
Centrifugal pump	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 55 kW	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 450 kW	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Attenuation to achieve 28 dB(A) at 2km from an IPF (i.e. at RF 2 or RF 6)								
First Stage Gas Compression Unit								
Screw compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 2000hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (2 fans, inlet plus outlet)	9	13	15	18	20	11	0	Cooler Treatment Package 3
Further Stages Gas Compression Unit								
Reciprocating compressor	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Electric motor - 5500hp	0	10	19	21	26	34	17	Enclosure Treatment Package 2
Cooler (3 fans, inlet plus outlet)	9	13	15	18	20	11	0	Cooler Treatment Package 3
Power Generation Plant								
Gas engine - air intake	0	2	3	5	8	2	0	Medium-grade muffler
Attenuation to achieve 28 dB(A) at 3km from an IPF (i.e. at RF 3 or RF 7)								
First Stage Gas Compression Unit								
Screw compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 2000hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (2 fans, inlet plus outlet)	2	8	10	16	14	10	00	Cooler Treatment Package 2
Further Stages Gas Compression Unit								
Reciprocating compressor	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Electric motor - 5500hp	0	8	8	11	21	24	16	Enclosure Treatment Package 1
Cooler (3 fans, inlet plus outlet)	15	18	22	28	30	25	10	Cooler Treatment Package 4

With the additional acoustic treatment incorporated in the design and the respective noise level reductions achieved (as provided in Tables 8.10 and 8.12), the noise levels at the reference locations have been modelled under worst-case meteorological conditions. The modelled noise level at each reference location for the three types of production facilities is summarised in Tables 8.13 to 8.15. Noise contours of the modelled noise levels from a 150 TJ/d IPF with additional acoustic treatment are provided in Appendix G.

Table 8.13: Modelled noise levels at reference locations from the production facilities with additional treatment to achieve 28 dB(A) at 1km (RF 1 and RF 5).

Reference Location	Distance (km) from Centre of Facility	Modelled Noise Level from the Production Facility with Additional Treatment		
		FCF	CGPF	IPF
RF 1	1	27	28	27
RF 2	2	17	18	18
RF 3	3	11	12	12
RF 4	5	<10	<10	<10
RF 5	1	27	28	28
RF 6	2	17	18	18
RF 7	3	11	13	12
RF 8	5	<10	<10	<10

Table 8.14: Modelled noise levels at reference locations from the production facilities with additional treatment to achieve 28 dB(A) at 2km (RF 2 and RF 6).

Reference Location	Distance (km) from Centre of Facility	Modelled Noise Level from the Production Facility with Additional Treatment		
		FCF	CGPF	IPF
RF 1	1	36	37	37
RF 2	2	26	27	27
RF 3	3	20	21	21
RF 4	5	12	13	12
RF 5	1	36	38	37
RF 6	2	27	28	27
RF 7	3	21	22	21
RF 8	5	13	14	13

Table 8.15: Modelled noise levels at reference locations from the production facilities with additional treatment to achieve 28 dB(A) at 3km (RF 3 and RF 7).

Reference Location	Distance (km) from Centre of Facility	Modelled Noise Level from the Production Facility with Additional Treatment		
		FCF	CGPF	IPF
RF 1	1	44	41	40
RF 2	2	33	32	30
RF 3	3	26	26	24
RF 4	5	16	18	16
RF 5	1	46	43	40
RF 6	2	34	33	31
RF 7	3	27	27	25
RF 8	5	17	19	16

The modelling indicates that the operational noise level at all reference locations can achieve the long term night-time noise criterion of 28 dB(A) with the additional acoustic treatment incorporated.

Low Frequency Noise

The noise from the proposed equipment at the production facilities are not dominated by low frequency noise (refer Table E.1 in Appendix E). With the application of the additional acoustic treatment (refer Tables 8.10 and 8.12), the low frequency content of some equipment will be significantly reduced, such as the coolers for the compressors. Notwithstanding, the propagation of sound over large distances will attenuate the high and mid frequencies, leaving a greater low frequency component which may open opportunity for complaint.

To ensure the low frequency noise from the production facilities achieves the draft guideline suggestion of $L_{pA,LF}$ of 20 dB(A) inside a dwelling, the low frequency noise inside a dwelling at the reference locations has been modelled under worst-case meteorological conditions. The model assumes that the appropriate additional acoustic treatment will be applied. The modelled noise level is provided in Table 8.16.

Table 8.16: Modelled low frequency noise levels (operation) from production facilities.

Reference Location	Distance (km) from Centre of Facility	Indoor Low Frequency Noise Criterion, dB(A)	Outdoor Noise Level Target for Applied Treatment	Modelled Noise Level, dB(A)		
				FCF	CGPF	IPF
RF 1	1	20	28 dB(A) at 1km	10	14	14
RF 2	2	20	28 dB(A) at 2km	11	12	9
RF 3	3	20	28 dB(A) at 3km	8	12	8
RF 4	5	20	No treatment	< 5	7	9
RF 5	1	20	28 dB(A) at 1km	11	15	15
RF 6	2	20	28 dB(A) at 2km	11	13	10
RF 7	3	20	28 dB(A) at 3km	8	12	9
RF 8	5	20	No treatment	< 5	8	9

The modelling indicates that the low frequency noise level inside a dwelling at the reference locations will be no greater than 15 dB(A) with the application of the recommended treatment. Therefore, the draft guideline suggestion of $L_{pA,LF}$ of 20 dB(A) inside a dwelling is achieved at all reference locations with the acoustic treatment (i.e., to achieve 28 dB(A) outside) in place.

Mitigation Measures for Short Term Noise Sources

The model indicates that the noise from gas flaring will achieve the short term night-time criterion of 28 dB(A) at reference locations located 2km (and greater) away from the facilities. The noise from flaring will not achieve the night-time criterion at reference locations located 1km from the facilities, however will achieve the criteria for other periods of the day.

In order to achieve the criteria at the reference locations located 1km away from the facilities (i.e., RF 1 and RF 5), the following mitigation measure options may be applied:

- Incorporating a combination of acoustic treatment such as pipe lagging and muffler to gas stream jets, and design measures such as appropriate flare port diameter; or,
- Restricting any planned flaring to the period between 6am and 10pm.

8.2 Production Wells and Pipelines

8.2.1 Reference Locations

The production wells will generally be located in a grid approximately 800m wide, with the associated water and gas pipelines linking the productions wells with production facilities. Although the selection of the production well locations has not been finalised, sensitive receptors will be located within or near the grid edge in many locations throughout the Surat Basin.

For the purpose of this assessment, the production wells are considered to be located in an 800m wide grid. Different separation distances of sensitive receptors from the nearest production well have been considered for noise modelling. For the modelling of operational noise, separation distances of 50m, 100m, 150m, 200m and 250m and 300m have been considered for sensitive receptors within or near the grid edge, measured from the location of the main equipment (i.e., generator and motor).

It is noted that Arrow will locate equipment associated with the production wells that produces noise at a minimum distance of 200m from a sensitive receptor. There may be infrastructure, which will be located within 200m of a sensitive receptor, such as the underground pipelines, however the infrastructure will not produce significant noise and will not have a noise impact at the sensitive receptor.

For the modelling of construction noise, separation distances of 50m, 100m, 150m, 200m, 250m, 500m, 750m and 1000m have been considered. The model separation distance is measured from the boundary of the construction site.

8.2.2 Existing Acoustic Environment

Similar to Section 8.1.2, a conservative approach was taken by assuming a low noise environment at the closest sensitive receptor to the sites.

8.2.3 Existing Arrow Contribution

In most circumstances, the gas wells will be located in areas without other existing Arrow noise sources. The exceptions will be where the grid of gas wells joins an existing grid or where the wells are to be located in the vicinity of existing production facilities. Each of these situations will need to be considered based on the individual circumstances.

For the purpose of this assessment, it is assumed that there is no noise contribution from existing Arrow facilities, consistent with the existing low noise environment assumption in Section 8.2.2.

8.2.4 Resultant Criteria

For a low noise environment, as determined in Section 8.2.2, the resultant noise criteria for the construction and operation of the production wells, in accordance with the Procedural Guide are provided in Table 8.17

Table 8.17: Noise criteria at sensitive receptors.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

It is noted that the noise criteria above are applied for both the operation and construction of the facilities. The criteria applied for construction noise are significantly more stringent than those that would typically be required by DERM for general construction work.

8.2.5 Meteorological Conditions for Noise Modelling

The worst-case (Category 6) meteorological conditions are considered to be the appropriate assessment conditions for the purpose of this assessment.

8.2.6 Typical Production Well Equipment

The main equipment at the production wells during operation are the electric motor of the well head, and the gas engine generator which generates electricity to power the electric motor. There are various types of generators currently used at existing gas wells. At certain locations, generators are not used as the electricity supply for the electric motor as it is obtained from the main power grid or from power generation at nearby production facilities

It is understood that Arrow is investigating the use of gas driven engines for power generation, ranging from 3 to 8 litres. However the reference case assumes 5.7L engines with 60kW motors, with the alternative option of the 60kW motors being supplied with electricity from the power grid (no gas engines).

Measurements of the noise from existing production wells with the 5.7L gas engine generator, water pump and motor, and just the water pump and motor (electricity from main power grid) have been made. The data have been analysed to determine the sound power levels. The resultant sound power levels are shown in the Table 8.18.

Table 8.18: Calculated sound power levels of the main noise sources at the production wells.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)									Total Sound Power Level (dB(A))
	31.5	63	125	250	500	1000	2000	4000	8000	
5.7L –V8 gas engine, Water pump 60kW motor	102	99	98	83	82	73	69	76	68	86
Water pump 60kW motor (electricity obtained from main power grid)	79	75	80	70	70	74	74	77	61	81

These sound power levels include the application of mufflers and enclosures to the gas engine generators of the existing production wells.

During normal operation, there will be no significant noise sources associated with the water and gas pipelines, which will be located underground.

8.2.7 Noise Modelling

Similar to the modelling for the production facilities, the noise from the construction and operation of the production wells have been modelled using the CONCAWE noise propagation model in the SoundPlan noise modelling software. Flat ground topography and, grass or rough pasture ground cover have also been assumed in the model given the typical characteristic of the project development area.

Construction Noise

The site selection for production wells and associated pipelines is currently not finalised. Considering the distance between the production wells, pipelines and the sensitive receptors will vary from site to site, modelling of noise from the construction sites have been made at assumed setback distances which represent the potential locations of the closest sensitive receptors from the site. The setback distances considered are 50m, 100m, 150m, 200m, 250m, 500m, 750m and 1000m.

Given detailed information regarding the construction equipment and techniques is not available, the noise modelling for the construction of each production well and associated pipelines have been based on typical construction activity and stages. The sound power levels of each piece of equipment have been based on AS 2436, manufacturer's data, or Sonus' database of noise sources, except for the completion drill rig which has been based on data provided in the Heggies "Gladstone LNG – Environmental Impact Statement Noise and Vibration (Terrestrial)" 2009 report.

Table 8.19 details the equipment and overall sound power levels included in this assessment, while Tables 8.20 and 8.21 detail the stages during the construction of the productions wells and associated pipelines, respectively.

The works associated with the abandonment of the production wells have also been considered in the construction noise assessment. The equipment used during the abandonment and the overall sound power levels of each piece of the equipment are provided in Table 8.22.

Table 8.19: Main noise sources during the construction of the production wells and associated pipelines.

Main Noise Source	Maximum Overall Sound Power Level (dB(A))
Construction Equipment	
Truck	120
Front end loader	118
Excavator	118
Dozer	120
Grader	118
Scraper	116
Rock saw	118
Crane	115
Bobcat	105
Drill rig	115
Generator	119
Welding generator	113
Air compressor	107
Hand-held grinder	106
Completion drill rig*	116
Process	
Flaring	93

***** Sound power level includes a drill rig, generators, booster pumps and mud pump.

Table 8.20: Equipment or process during the construction stages of the production wells considered.

Construction Stage	Equipment or Processes
Site preparation, clear and grade	Truck Front end loader Excavator Scraper Dozer Grader
Drilling	Drill rig Generator Truck Front end loader
Completion and workover	Completion drill rig (drill rig, generators, booster pumps and mud pump)
Surface equipment installation	Bobcat Truck Generator Air Compressor Front end loader
Commissioning and testing	Flaring - 0.02 TJ/day
Site rehabilitation	Grader Front end loader Excavator Truck

Table 8.21: Equipment or process during the construction stages of the pipelines considered.

Construction Stage	Equipment or Processes
Site preparation, clear and grade	Truck Front end loader Scraper Dozer Grader
Trenching, stringing and lowering in	Rock saw Excavator Truck Crane
Pipe joining and welding	Welding generator Generator Air compressor Hand-held grinder
Pressure testing	Generator Air compressor
Backfilling	Truck Excavator Front end loader Grader
Site rehabilitation	Grader Front end loader Excavator Truck

Table 8.22: Equipment or process during the abandonment stages of the production wells considered.

Abandonment Stage	Equipment or Processes
Equipment disassembly and removal	Generator Air compressor Hand-held grinder Excavator Truck Crane
Backfilling	Truck Excavator Front end loader Grader
Site rehabilitation	Grader Front end loader Excavator Truck

Based upon the above equipment and sound power levels, modelling of the noise from construction of the production wells and associated pipelines and the abandonment of production wells at the defined setback distances have been made under worst-case meteorological conditions.

The modelling assumes a “worst-case” period of all considered equipment operating simultaneously and continuously within the respective site area. The modelled noise levels are provided in Tables 8.23 through 8.25.

Table 8.23: Modelled noise levels from the construction of production wells.

Construction Stage	Equipment or Processes	Modelled Noise Level, dB(A)							
		50m	100m	150m	200m	250m	500m	750m	1000m
Site preparation, clear and grade	Truck	74	69	66	63	61	54	48	44
	Front end loader	72	67	63	61	59	51	47	43
	Excavator	67	64	61	59	57	50	46	42
	Scraper	65	61	58	56	54	48	44	41
	Dozer	75	70	66	63	61	54	49	45
	Grader	67	63	60	58	56	50	46	43
	Total	**79**	**74**	**71**	**68**	**66**	**59**	**54**	**51**
Drilling	Drill rig	67	63	60	57	55	48	44	41
	Generator	71	66	63	61	59	52	48	44
	Truck	73	68	65	63	61	53	48	44
	Front end loader	71	66	63	60	58	51	47	43
	Total	**77**	**72**	**69**	**67**	**65**	**57**	**53**	**49**
Completion and Workover	Completion drill rig (comprising a drill rig, generators, booster pumps and mud pump)	68	64	61	58	56	50	45	42
	Total	**68**	**64**	**61**	**58**	**56**	**50**	**45**	**42**
Surface equipment installation	Bobcat	58	53	50	48	46	38	34	31
	Truck	73	68	65	63	61	53	48	44
	Generator	71	66	63	61	59	52	48	44
	Air compressor	59	54	51	49	47	40	36	32
	Front end loader	72	68	64	62	60	53	48	45
	Total	**77**	**72**	**69**	**67**	**65**	**58**	**53**	**49**
Commissioning and Testing	Flaring	45	41	38	37	33	24	18	14
	Total	**45**	**41**	**38**	**37**	**33**	**24**	**18**	**14**
Site rehabilitation	Grader	67	36	60	58	56	50	46	43
	Front end loader	72	67	63	61	59	51	47	43
	Excavator	67	64	61	59	57	50	46	42
	Truck	74	69	66	63	61	54	48	44
	Total	**77**	**72**	**69**	**67**	**65**	**58**	**53**	**49**

Table 8.24: Modelled noise levels from the construction of pipelines.

Construction Stage	Equipment or Processes	Modelled Noise Level, dB(A)							
		50m	100m	150m	200m	250m	500m	750m	1000m
Site preparation, clear and grade	Truck	76	70	67	64	62	54	48	43
	Front end loader	73	67	64	61	59	52	47	44
	Scraper	72	66	62	59	56	49	45	41
	Dozer	76	70	66	63	61	54	49	45
	Grader	74	68	64	61	58	51	47	43
	Total	**82**	**76**	**72**	**69**	**66**	**59**	**55**	**51**
Trenching, stringing and lowering in	Rock saw	74	68	64	61	58	51	47	43
	Excavator	75	69	65	62	60	52	47	43
	Truck	75	70	67	64	62	54	49	44
	Crane	71	65	61	59	56	49	44	41
	Total	**80**	**74**	**71**	**68**	**66**	**58**	**53**	**49**
Pipe joining and welding	Hand-held grinder	61	56	53	50	48	39	33	29
	Generator	74	69	65	62	60	53	48	45
	Welding generator	70	64	60	57	55	47	42	39
	Air compressor	62	57	53	50	48	41	36	33
	Total	**76**	**71**	**67**	**64**	**62**	**54**	**49**	**46**
Pressure testing	Generator	74	69	65	62	60	53	48	45
	Air compressor	62	57	53	50	48	41	36	33
	Total	**74**	**69**	**65**	**62**	**60**	**53**	**48**	**45**

Table 8.24: Modelled noise levels from the construction of pipelines (continued).

Construction Stage	Equipment or Processes	Modelled Noise Level, dB(A)							
		50m	100m	150m	200m	250m	500m	750m	1000m
Backfilling	Truck	76	70	67	64	62	54	48	43
	Excavator	75	69	65	62	60	52	47	43
	Front end loader	73	67	64	61	59	52	47	44
	Grader	74	68	64	61	58	51	47	43
	Total	**81**	**75**	**71**	**68**	**66**	**58**	**53**	**49**
Site rehabilitation	Grader	74	68	64	61	58	51	47	43
	Front end loader	73	67	64	61	59	52	47	44
	Excavator	75	69	65	62	60	52	47	43
	Truck	76	70	67	64	62	54	48	43
	Total	**81**	**75**	**71**	**68**	**66**	**58**	**53**	**49**

Table 8.25: Modelled noise levels from the abandonment of production wells.

Construction Stage	Equipment or Processes	Modelled Noise Level, dB(A)							
		50m	100m	150m	200m	250m	500m	750m	1000m
Equipment disassembly and removal	Generator	74	69	65	62	60	53	48	45
	Air compressor	62	57	53	50	48	41	36	33
	Hand-held grinder	61	56	53	50	48	39	33	29
	Excavator	75	69	65	62	60	52	47	43
	Truck	76	70	67	64	62	54	48	43
	Crane	71	65	61	59	56	49	44	41
	Total	**80**	**75**	**71**	**68**	**66**	**59**	**53**	**49**
Backfilling	Truck	76	70	67	64	62	54	48	43
	Excavator	75	69	65	62	60	52	47	43
	Front end loader	73	67	64	61	59	52	47	44
	Grader	74	68	64	61	58	51	47	43
	Total	**81**	**75**	**71**	**68**	**66**	**58**	**53**	**49**
Site rehabilitation	Grader	74	68	64	61	58	51	47	43
	Front end loader	73	67	64	61	59	52	47	44
	Excavator	75	69	65	62	60	52	47	43
	Truck	76	70	67	64	62	54	48	43
	Total	**81**	**75**	**71**	**68**	**66**	**58**	**53**	**49**

The modelling indicates that the noise at the potential sensitive receptor points (up to 1km away from the construction site), during the different stages of construction and adandonment of the production wells, and construction of the associated pipelines will exceed the established criteria for all periods of the day, except for flaring during the commissioning of production wells. Mitigation measures to reduce the noise impact at sensitive receptors from construction or abandonment activity associated with the production wells and pipelines are provided in Section 8.2.8.

Operational Noise

Using the calculated sound power levels provided in Table 8.18, the noise from the production wells was modelled under worst-case meteorological conditions at potential locations of sensitive receptors described by separation distances from the nearest well, either within a well grid space or at the grid edge. The initial modelling includes no additional acoustic treatment and the results are shown in Tables 8.26 and 8.27.

Table 8.26: Modelled noise levels at potential sensitive receptors within the well grid.

Distance to Nearest Gas Well (m)	Modelled Noise Level (dB(A))	
	5.7L-V8 Generator, 60 kW Motor	60 kW Motor only (Electricity obtained from main power grid)
50	44	39
100	38	33
150	34	29
200	31	26
250	30	24
300	28	23

Table 8.27: Modelled noise levels at potential sensitive receptors near the well grid edge.

Distance to Nearest Gas Well (m)	Modelled Noise Level (dB(A))	
	5.7L-V8 Generator, 60 kW Motor	60kW Motor only (Electricity obtained from main power grid)
50	44	39
100	38	33
150	34	29
200	31	26
250	29	24
300	27	22

With the use of the 5.7L-V8 gas engines, the present level of acoustic treatment (i.e., measured noise level of 54 dB(A) at 10m from the equipment) is sufficient to achieve a level of 28 dB(A) if the sensitive receptor is located within the grid at least 300m from the closest production well. If the sensitive receptor is located outside of the grid, the present level of treatment is sufficient to achieve 28 dB(A) if the sensitive receptor is located at least 270m from the closest production well.

8.2.8 Mitigation Measures

Construction Noise

In order to reduce the noise impact at sensitive receptors, similar mitigation measures as those for the construction of the production facilities will be implemented, which will include:

- standard management and construction noise mitigation measures (refer Section 8.1.8 for Construction Noise);
- noise modelling or monitoring at the start of each known construction activity, particularly at night which will result in noise at sensitive receptors. The exercise will ensure that the activity will not result in significant noise impact at sensitive receptors, and;

- community liaison and communication when noise from certain construction activity may exceed the criteria. Such an approach will provide awareness to the community regarding the nature of the construction activity and will lessen the potential for unexpected noise.

It is noted that the applied criteria for construction of the project is significantly more stringent that those typically applied to general construction works. The expected noise from construction activity will not be dissimilar from other construction sites.

Operational Noise

Where the modelled noise from the production wells exceeds the allowed contribution at the sensitive receptor, mitigation measures can be applied to achieve the relevant criteria. These measures could take the form of a noise barrier to block line of sight between the gas engines or generator and the sensitive receptor; acoustic treatment or additional measures to reduce the noise from the gas engines and generator; the use of mains power to eliminate the need for a generator; or the placement of the closest production well at a greater distance from the sensitive receptor.

As an example, if a 3.5m high barrier were to be placed to block line of sight between the closest production well (with a 5.7L-V8 gas engine) and the sensitive receptor, the distance between the sensitive receptor and the well could be reduced to 80m, whist still achieving a contribution of 28 dB(A).

9 NOISE IMPACT ASSESSMENT PROCEDURE

At this stage of the development, the site location and design of the production facilities and production wells are yet to be finalised. As such, a noise impact assessment (refer Section 8) has been conducted based on typical site layout and indicative equipment, with the site being located in an environment typical of the project development area (i.e., low noise environment with no noise contribution from existing Arrow plant).

The noise impact assessment indicated that the noise from the construction and operation of the project for the considered scenario can achieve the established noise criteria (in accordance with the Procedural Guide) at sensitive receptors with the application of appropriate mitigation measures.

In addition to the noise impact assessment conducted, a procedure has been developed to ensure that the noise from the construction and operation of the project achieves the established noise conditions at sensitive receptors for a specific development site or scenario.

9.1 Site Selection

Environmental noise will be one of a number of factors that need to be taken into account when sites are selected. From an environmental noise perspective, the most critical factor in the site selection is the separation distance that can be achieved between the proposed facilities and sensitive receptors.

The separation distance between production facilities and sensitive receptors will be maximised by selecting sites in sparsely populated areas where practical. It might be possible to also use the natural topography in the vicinity of the site to provide a barrier between the facility sites and some sensitive receptors, although this is likely to be rare, given the relatively flat topography within the project development area.

The production wells will generally be located in a grid of approximately 800m wide, spanning the project development area. Many sensitive receptors will therefore be located within or near the grid edge. Although from an operational perspective, the wells would ideally be placed in a regular grid, it might be necessary to consider the local placement of some wells, where the well location would otherwise be close to a sensitive receptor.

9.2 Determination of Existing Acoustic Environment

Based on the background noise monitoring conducted within the project development area, it is likely that most of the sensitive receptors in the vicinity of the development will have an existing low noise environment.

Once the site for a particular production facility or production well has been selected, a desktop assessment of the existing acoustic environment at the closest sensitive receptor to the site will be conducted to confirm the existing noise environment. Where the existing acoustic environment at the sensitive receptor may be influenced by existing noise sources in the vicinity (noise sources not associated with the CSGI, such as road traffic), additional background noise monitoring at the sensitive receptor may be conducted to establish alternative noise criteria for the site, in accordance with the Procedural Guide.

9.3 Determination of Existing Arrow Contribution

The contribution of noise from any existing Arrow facilities at the closest sensitive receptor to the sites selected will also be determined. In many situations there will be no existing Arrow facilities in the vicinity but where there are existing facilities, the contribution of noise will be determined either by direct measurement or by noise modelling based on the measurement of noise from similar facilities.

The level of contribution will then be considered in the noise modelling to ensure that the combined total noise from new and existing Arrow facilities achieves the relevant criteria.

9.4 Determination of Resultant Criteria

The applied noise criteria will be based on the existing acoustic environment at sensitive receptors. There are three existing acoustic environment scenarios which may apply at the sensitive receptors, as described in Section 7.1.5. Each scenario will result in different noise criteria at the sensitive receptor. The applicable scenario of sensitive receptors is determined based on steps 9.2 and 9.3.

9.5 Determination of Assessment Meteorological Conditions

Once the sites for the production facilities and production wells have been selected, the locations of sensitive receptors in the vicinity of each site will be identified. With the relative direction of sensitive receptors from each development site known, the relevant meteorological conditions noise modelling at each sensitive receptor is determined based on the analysis conducted in Section 6.

For sensitive receptors located to the west and northwest from a site, the neutral meteorological conditions (Category 4) are considered the appropriate assessment conditions, while for sensitive receptors located in all other directions, the worst-case meteorological conditions (Category 6) are appropriate.

For sensitive receptors in the vicinity of the production wells (i.e, either within or near well grid), it is likely that the sensitive receptor will have noise contributions from multiple productions wells located in various directions. Under these circumstances, the worst-case (Category 6) meteorological conditions are considered appropriate, even though the closest well may be located to the east or southeast.

9.6 Equipment Selection

The selection of equipment will obviously influence the overall noise level at the sensitive receptors. Different types of equipment (i.e. make, model, capacity, etc) will emit different levels of noise. Therefore, the sound power levels produced by the equipment and the presence of any tonality will be key considerations in the final equipment selection.

It is understood that the same standard equipment will be selected for all of the production facilities and production wells. Much of the equipment will include acoustic treatment measures, such as mufflers, low noise fans and possibly enclosures. Even with these measures in place, additional acoustic treatment may be required for some sites depending on the noise restrictions at the specific location.

9.7 Noise Modelling

The CONCAWE noise propagation model in the SoundPlan noise modelling software will be used to model the noise from the sites to the closest sensitive receptors. The CONCAWE propagation model takes into account topography, ground absorption, air absorption and meteorological conditions, and has been used and accepted around the world as an appropriate sound propagation model for predicting noise over significant distances.

9.7.1 Construction Noise

The modelling of noise from construction activity will be based on detailed information of the construction equipment and techniques used on site. Where the information is not available, the noise model will assume typical construction equipment on site with all equipment operating continuously and simultaneously. The appropriate meteorological conditions for the noise model will be determined in step 9.5.

9.7.2 Operational Noise

Based on the selected equipment, the noise from the equipment will be modelled using the sound power levels provided by the equipment manufacturers or calculated based on measured noise levels from equivalent equipment and the likelihood of tonality will be determined. The noise will be modelled under the appropriate meteorological conditions determined in step 9.5.

9.8 Potential Impacts and Mitigation Measures

9.8.1 Construction Noise

Comparison of the modelled noise levels will be made against the relevant project criteria. Where required, all reasonable and practicable mitigation measures will be considered, including restricting the period of the day for the construction activity.

9.8.2 Operational Noise

The modelled noise level at sensitive receptors will be used to determine the potential noise impacts from the project. Where the modelled noise from the operation of the facilities exceeds the established noise criteria, mitigation measures and additional acoustic treatment will be designed to achieve the criteria. The acoustic treatment might take the form of acoustic enclosures, noise barriers, higher performance mufflers or the use of alternate technology or equipment.

10 VIBRATION IMPACT ASSESSMENT

The level of vibration at sensitive receptors is dependent on the equipment operating (i.e., the vibration source), and the separation distance and ground type between the sensitive receptors and the vibration sources. These factors have been considered in determining the potential vibration impact on sensitive receptors from the project.

The assessment considered the vibration level at sensitive receptors from the operation and construction of the production facilities, the production wells, and the associated water and gas pipelines.

10.1 Construction

At this stage of the development, detailed information on the exact equipment and construction techniques that will be implemented for the construction of the project is not known.

Based on the vibration levels produced from typical construction activity, and the large separation distances between the construction site of the production facilities and sensitive receptors (in the order of kilometres), the expected vibration level at sensitive receptors from construction activities will be well below the threshold of human detection.

For the construction of the production wells and associated pipelines, the distance between the construction activity and the closest sensitive receptor will vary significantly from site to site, which will affect the vibration levels expected. Where the construction activity occurs at distances greater than 100m from sensitive receptors, the vibration level at the sensitive receptors is expected to not be significant.

Where the construction activity occurs within 100m from a sensitive receptor and there is the potential for vibration at the sensitive receptor, vibration monitoring will be conducted during the construction activity. The vibration monitoring at the sensitive receptor will ensure that the established vibration criteria for the prevention of structural damage are achieved.

10.2 Operation

Sonus has previously conducted vibration measurements at similar facilities which had similar equipment operating on site. The measurements indicated that the vibration levels were well below the threshold of human detection at a distance of 100m from the facility. Therefore, considering the closest sensitive receptor to the production facilities and productions wells will likely be greater than 100m, it is expected that the vibration levels will be below the threshold of human detection and will not cause structural damage.

The associated water and gas pipeline will be located underground, and it is understood that there will be no equipment which will produce significant vibration. The vibration levels at the closest sensitive receptors from the pipelines are expected to be well below the threshold of human detection.

11 BLASTING IMPACT ASSESSMENT

At this stage of the development, blasting work associated with the project construction during site preparation is not proposed. However, the following consideration has been included in this assessment to ensure that the noise and vibration impact at sensitive receptors will not be significant, should the need for blasting arise.

Prior to any blasting operation being conducted, the factors which influence the measured noise and vibration levels will be considered. These include:

- the type of rock and stratography/faulting;
- the distance between the blast site and the residence;
- the type, size and number of charges used;
- the depth and manner in which the charge is installed, and;
- meteorological conditions.

The blasting operation will therefore be designed and adjusted by professional blast providers to ensure that the vibration and noise level criteria provided by the *Environmental Protection Act 1994* and DERM “Noise and vibration from blasting” Guideline are achieved at all sensitive receptors in the vicinity of the operation.

12 OFF-SITE TRAFFIC IMPACT ASSESSMENT

The noise and vibration impact on sensitive receptors from off-site traffic generated by the project has been determined based on the outcomes of the road impact assessment summarised in the Cardno Eppel Olsen “Surat Gas Impact Assessment Report – Road Impact Assessment” 2011 report (the RIA Report).

12.1 Road Impact Assessment

The road impact assessment states the following in the RIA Report:

> *Project-generated traffic is anticipated to peak in 2035 with approximately 29,130,000 vehicle kilometres travelled. Strategic modelling estimated project-generated travel in the peak year (2035) is likely to be less than 1% of the total travel that occurred across DTMR’s Darling Downs district road network in 2009. At its peak, the project is anticipated to increase the extent of heavy-vehicle travel occurring on the district’s road network by less than 2% of the existing (2009) levels, and the extent of light-vehicle travel by less than 1% of existing (2009) levels.*

12.2 Noise and Vibration Impact Assessment

Based on the anticipated vehicle (heavy and light) travel increase of less than 2% on the road network, the noise levels at sensitive receptors from road traffic will increase by no greater than 0.1 dB(A) above the current level. From a noise perspective, a 0.1 dB(A) increment is considered negligible and will not result in a change of impact at sensitive receptors.

Similarly for vibration, the impact from the “additional” vehicles on the road will not be dissimilar to the impact from existing vehicles using the road network. Therefore, the vibration impact from traffic generated by the project is not expected change the existing impact at sensitive receptors.

13 CUMULATIVE IMPACT ASSESSMENT

The cumulative noise and vibration impact of the project, existing developments and projects with an approved EIS, which are located in the Surat Basin has been considered.

13.1 Cumulative Noise Impact

13.1.1 Cumulative Noise from Arrow Plant

The cumulative noise from new and existing Arrow plants, and noise from other sources not associated with the CSGI have been taken into account in the proposed noise conditions, which are in accordance with the Procedural Guide.

Based on the noise modelling conducted in this assessment, and the indicative spreading of the production facilities within the project development area (which will generally be not less than 10km apart), the cumulative noise from multiple Arrow facilities at the sensitive receptors will achieve the proposed conditions with the application of appropriate treatment. For example, considering a low noise environment at a sensitive receptor located 2km from a facility, the 28 dB(A) criterion can be achieved with appropriate treatment incorporated, and in addition, allow noise contributions from other Arrow facilities with similar treatment incorporated.

The noise modelling also indicates that the cumulative noise from Arrow production facilities and the production wells can achieve the proposed noise conditions with the appropriate combination of acoustic treatment applied to the facilities and production wells. The required acoustic treatment in order to achieve the noise conditions can be determined with the implementation of the assessment procedure.

13.1.2 Cumulative Noise from the CSGI

Within the Surat Basin, there are several other industry proponent projects which will be operating in the region, such as Australia Pacific LNG Project, Gladstone LNG Project and the Queensland Curtis LNG Project. The operations of each project will be confined within the petroleum lease (PL) area, or project development area, of each project.

For each project, similar activities will be conducted. The production wells will be located in a similar grid, and the production located at similar distances apart. As such, provided that each project achieves the noise conditions in accordance with the Procedural Guide, the cumulative noise at sensitive receptors from the CSGI is expected to also achieve the noise conditions provided by the Procedural Guide.

13.2 Cumulative Vibration Impact

Based on the vibration impact assessment, the vibration levels at sensitive receptors from the operation of the project are expected to be below the threshold of human detection. Considering the large separation distances between the different projects (i.e., greater than 100m), it is expected that the cumulative vibration from industry in the Surat Basin region will not have a significant impact on sensitive receptors.

14 POTENTIAL IMPACT ON LIVESTOCK

The potential impact of noise and vibration on livestock located close to the project infrastructure has been assessed based on the noise modelling and the vibration impact assessment.

Based on the modelled noise from the production facilities and production wells, the livestock will experience noise levels not dissimilar to levels prevalent in areas adjacent to roads, rail or existing production wells and facilities.

For example, the expected noise experienced by livestock outside of the site boundary of a production facility with appropriate acoustic treatment applied (e.g., to achieve 28dB(A) at 2km from the facility), or outside of the site boundary of a typical production well (5.7L gas powered engine) is in the order of 60 dB(A), which is similar to the noise level expected when grazing adjacent to roads or rail.

Based on the vibration impact assessment, the vibration level experienced by livestock outside of the site boundaries of the production facilities and production wells will be similar to when grazing near roads or rail.

15 CONCLUSION

This assessment has considered environmental noise from the operation and construction of the Surat Gas Project, which consists of the production facilities, production wells, and the associated water and gas pipelines.

Based upon the DERM released "Coal Seam Gas Industry Procedural Guide – Control of Noise from Gasfield Activities" (the Procedural Guide), appropriate criteria for noise from construction and operation of the project have been proposed. The proposed criteria take into account the different scenarios of the existing noise environment at sensitive receptors, which are summarised below:

Scenario 1 – For sensitive receptors with a low noise environment.

Time Period	Descriptor	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins}$	45 dB(A)	43 dB(A)	40 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins}$ max $L_{p,A,15mins}$	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)	28 dB(A) 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins}$	40 dB(A)	38 dB(A)	35 dB(A)

Scenario 2 – For sensitive receptors with background noise levels which are greater than the minimum deemed background noise level of the Procedural Guide, and have no influence from the existing Arrow plant.

Time Period	Short Term Noise Event	Medium Term Noise Event	Long Term Noise Event
7:00am - 6:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
6:00pm - 10:00pm	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)
10:00pm - 6:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 3 dB(A) max $L_{p,A,15mins} \leq$ 55 dB(A)
6:00am - 7:00am	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 10 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 8 dB(A)	$L_{Aeq,adj,15mins} \leq L_{ABG,T}$ + 5 dB(A)

Scenario 3 – For sensitive receptors with noise influence from existing Arrow plant.

Time Period	Noise Criteria
All periods	Total noise level (new and existing Arrow plant) no greater than the existing Arrow plant noise contribution.

As the sites and the equipment to be installed at the production facilities and production wells are yet to be finalised, a noise modelling assessment has been conducted based on a typical site layout and indicative equipment, with the site being located in an environment typical of the project development area. The modelling indicated that the noise from the construction and operation of the project can achieve the proposed noise conditions with practicable acoustic treatment and mitigation measures.

In addition to the noise modelling conducted for the noise impact assessment, a procedure has been developed to ensure that the noise from the project achieves the relevant criteria at sensitive receptors and does not adversely affect the environment.

To objectively assess the impact of vibration from the project, reference was made to the Australian Standard AS 2670.2-1990 and German Standard DIN 4150.3-1999, which provide the appropriate criteria for ensuring human comfort and the prevention of structural damage to buildings, respectively. Depending on the equipment and the separation distance of the development site from the sensitive receptors, the vibration from the operation and construction of the project is not expected to be significant. Where there is potential for vibration at sensitive receptors, vibration monitoring will be conducted.

The noise and vibration impact from off-site traffic generated by the traffic has been considered based on the anticipated traffic growth percentage. The assessment determined that the generated traffic from the project will not result in a change of existing impact at the sensitive receptors.

The cumulative noise and vibration impact of the project, existing developments, and projects with an approved EIS which are located in the Surat Basin region has also been considered. With each project achieving the noise conditions provided by the Procedural Guide, the cumulative noise from the project and other CSGI projects will not have a significant impact on sensitive receptors. The cumulative vibration from the industry will not have a significant impact on sensitive receptors given the large separation distances (i.e., greater than 100m) of sensitive receptors from the potential vibration sources.

Given that blasting is not currently proposed, the detailed information (e.g., location and frequency) of any blasting requirements at the construction sites is not assessed. It is assumed that should blasting be undertaken, each blast will be designed and adjusted by professional blast providers to ensure that the noise and vibration criteria provided by the *Environmental Protection Act 1994 and* the DERM "Noise and vibration from blasting" Guideline are achieved.

Based on the noise and vibration impact assessments, analysis of the potential impact of noise and vibration on livestock located close to facilities has been conducted. Based on the application of appropriate acoustic treatment at the facilities (e.g., to achieve 28dB(A) at 2km from the facility), and the typical production well equipment (5.7L gas powered engine), the noise experienced by livestock outside of the site boundaries is expected to be no greater than the noise experienced when grazing adjacent to roads. No significant vibration impact is expected to be experienced by livestock.

16 REFERENCES

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APPENDIX A: SURAT GAS PROJECT DEVELOPMENT AREA

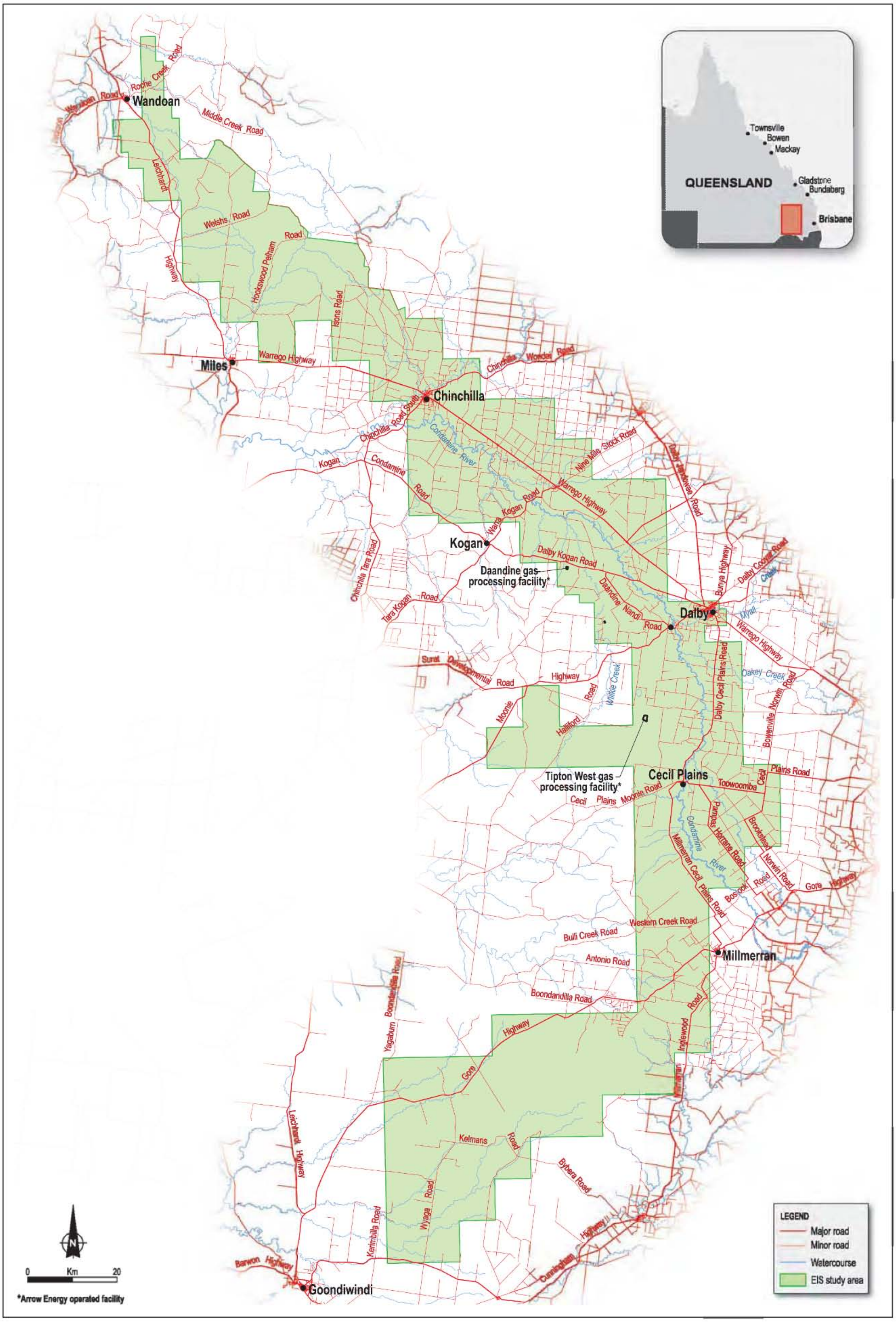


Figure A.1: Surat Gas Project development area.

APPENDIX B: APPROXIMATE NOISE MONITORING LOCATIONS

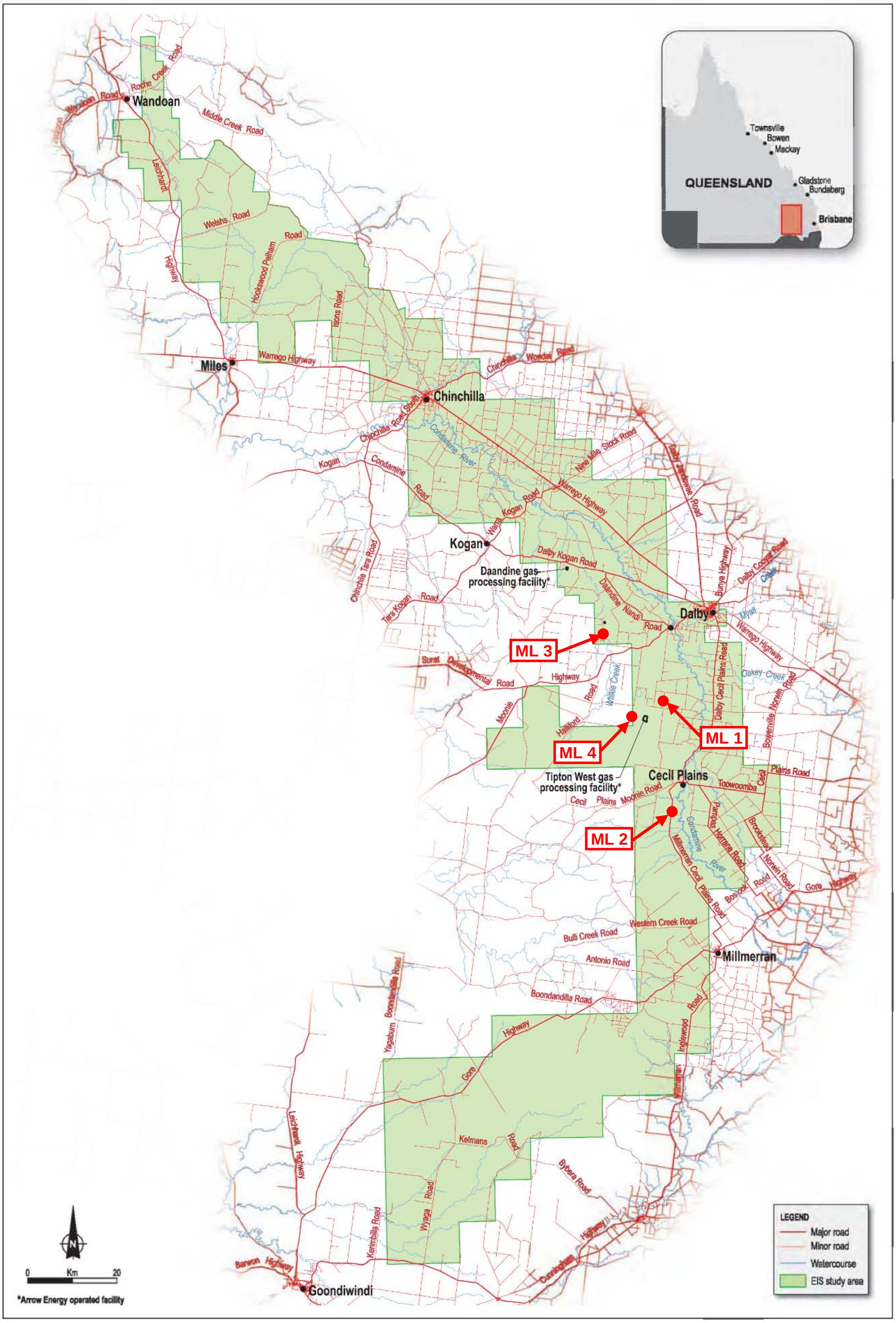


Figure B.1: Approximate noise monitoring locations.

APPENDIX C: MEASURED BACKGROUND NOISE LEVELS

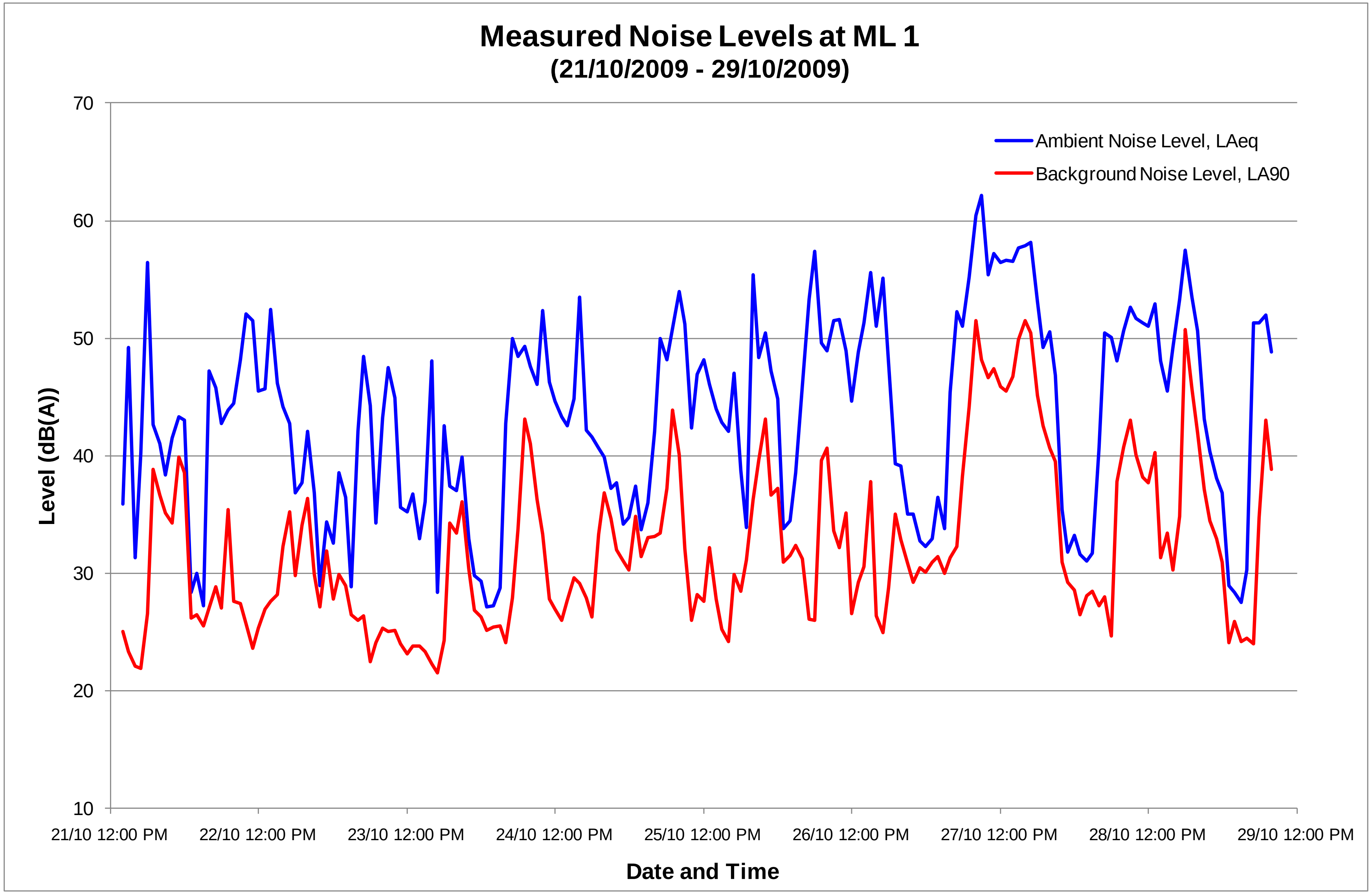


Figure C.1: Measured ambient and background noise levels at ML 1.

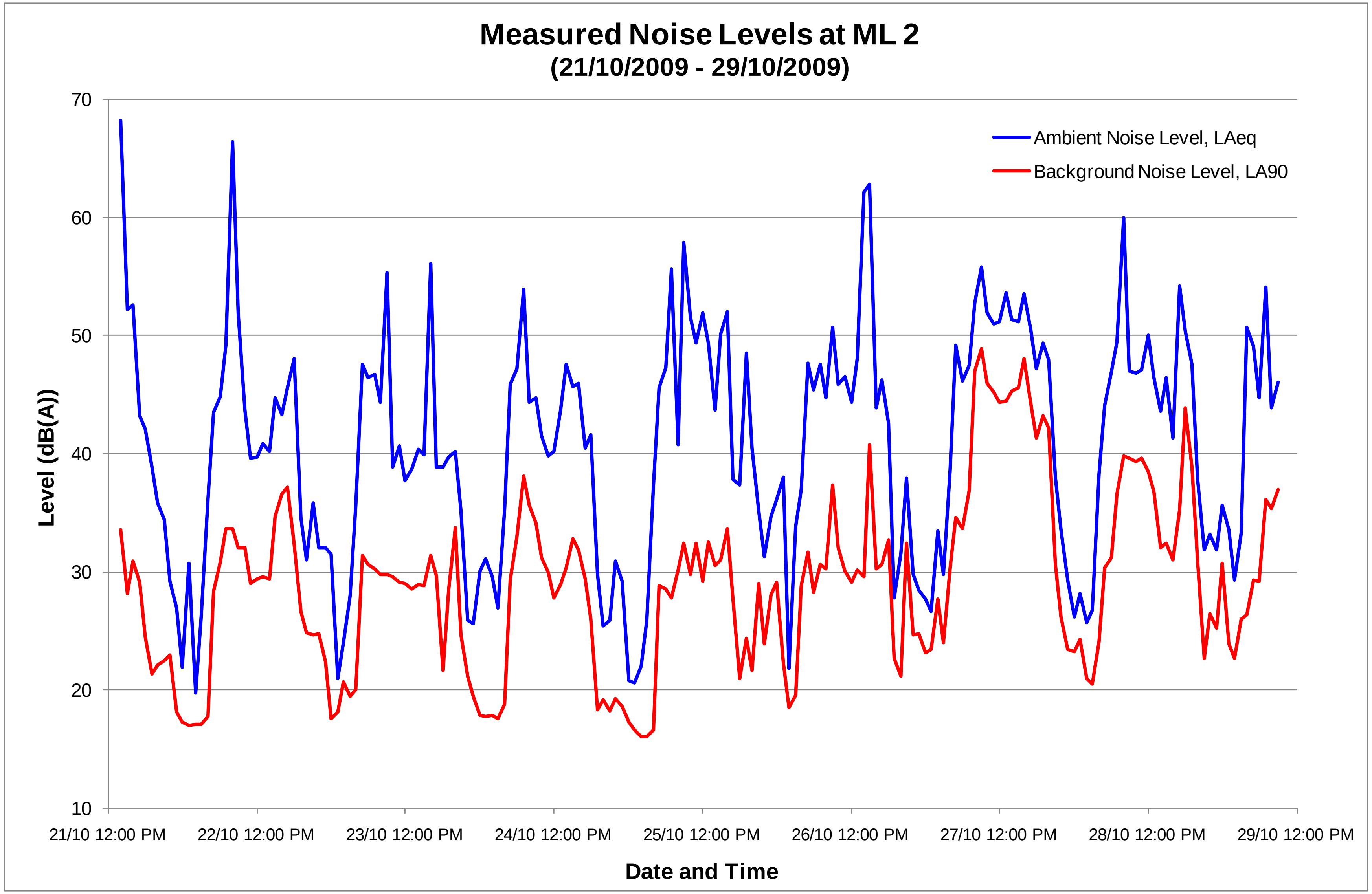


Figure C.2: Measured ambient and background noise levels at ML 2.

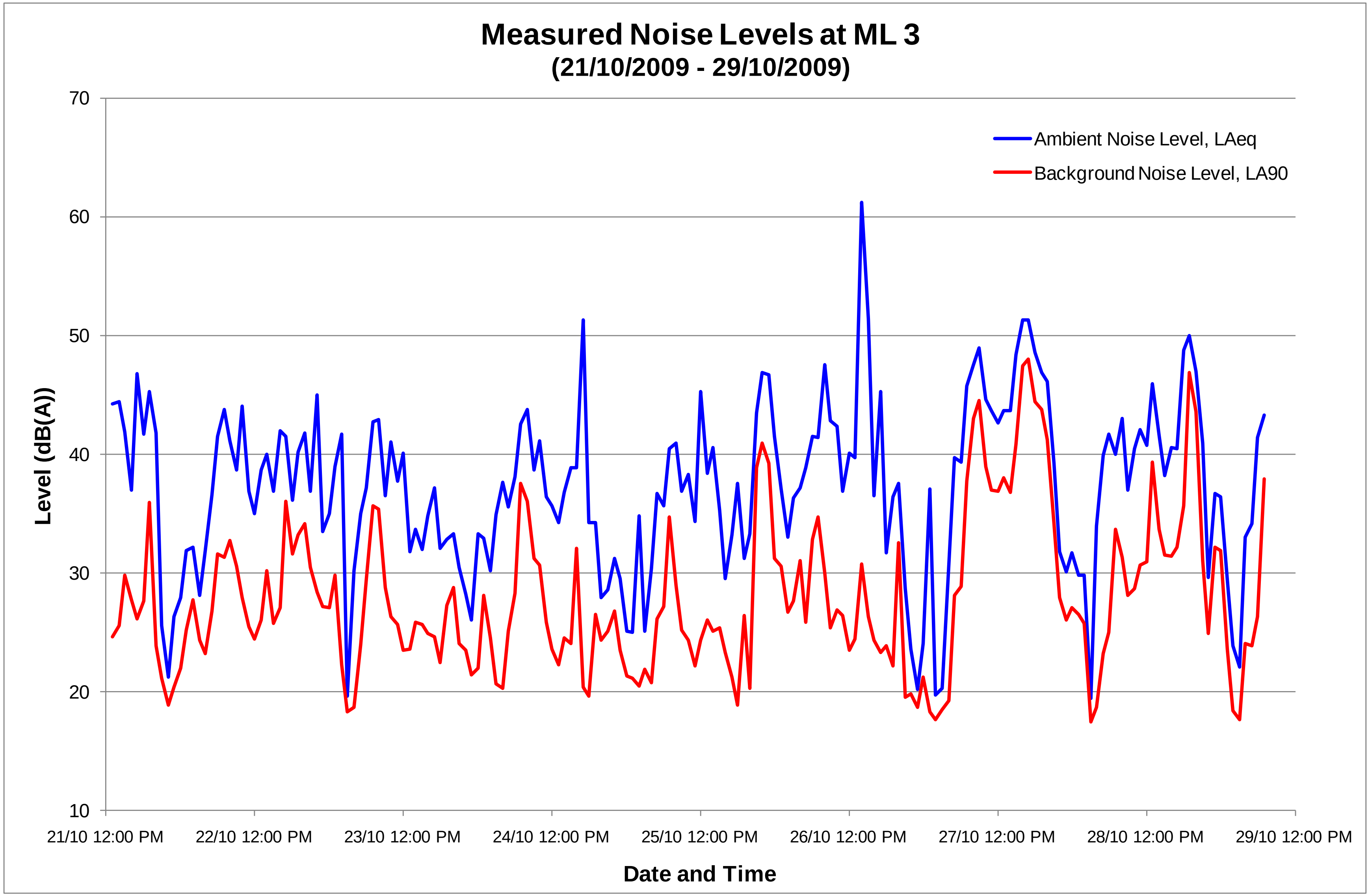


Figure C.3: Measured ambient and background noise levels at ML 3.

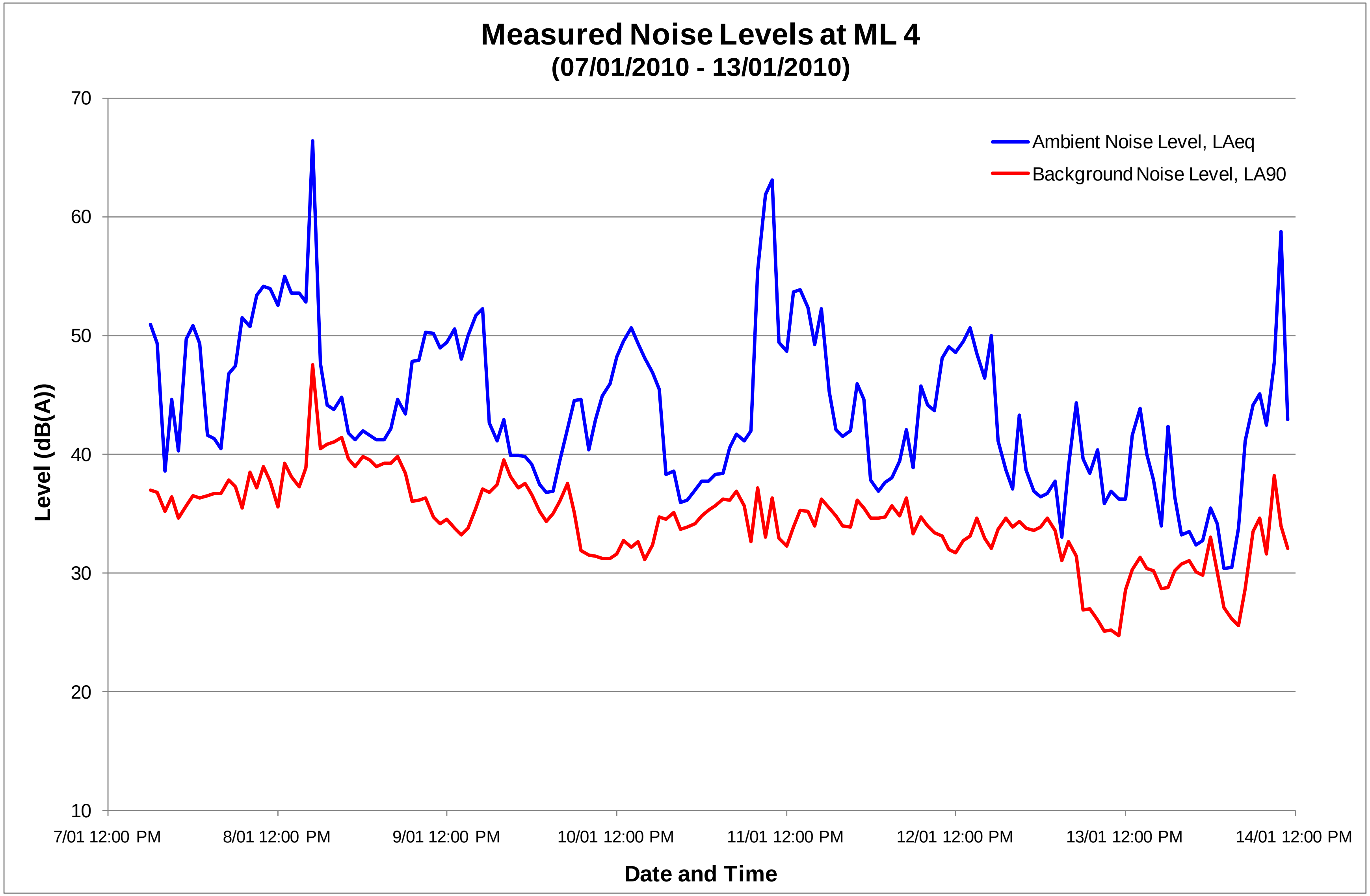


Figure C.4: Measured ambient and background noise levels at ML 4.

APPENDIX D: CONCEPTUAL LAYOUT OF A PRODUCTION FACILITY

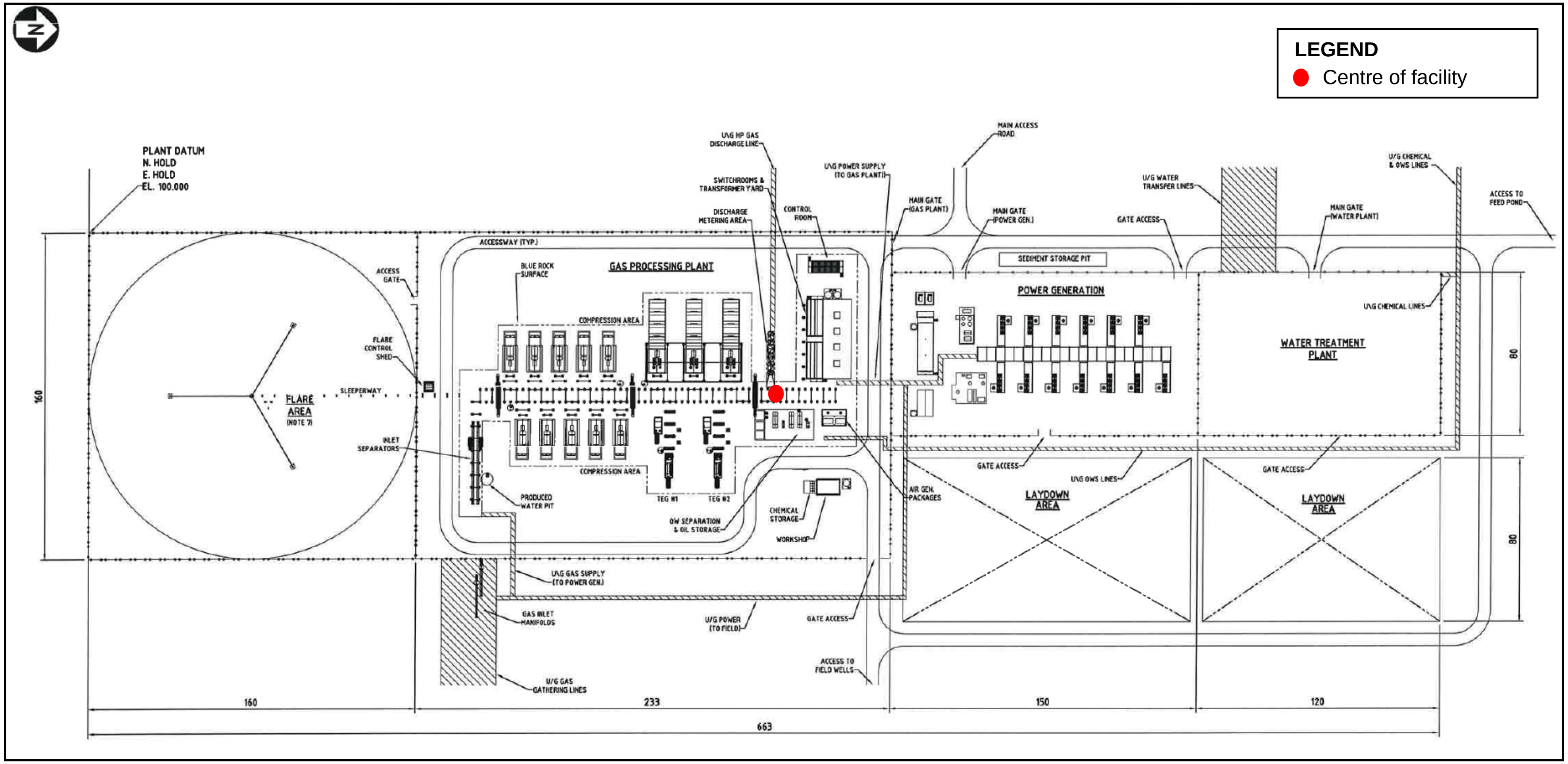


Figure D.1: Conceptual layout of a production facility (a 96 TJ/d IPF).

APPENDIX E: MAIN NOISE SOURCES AND SOUND POWER LEVELS

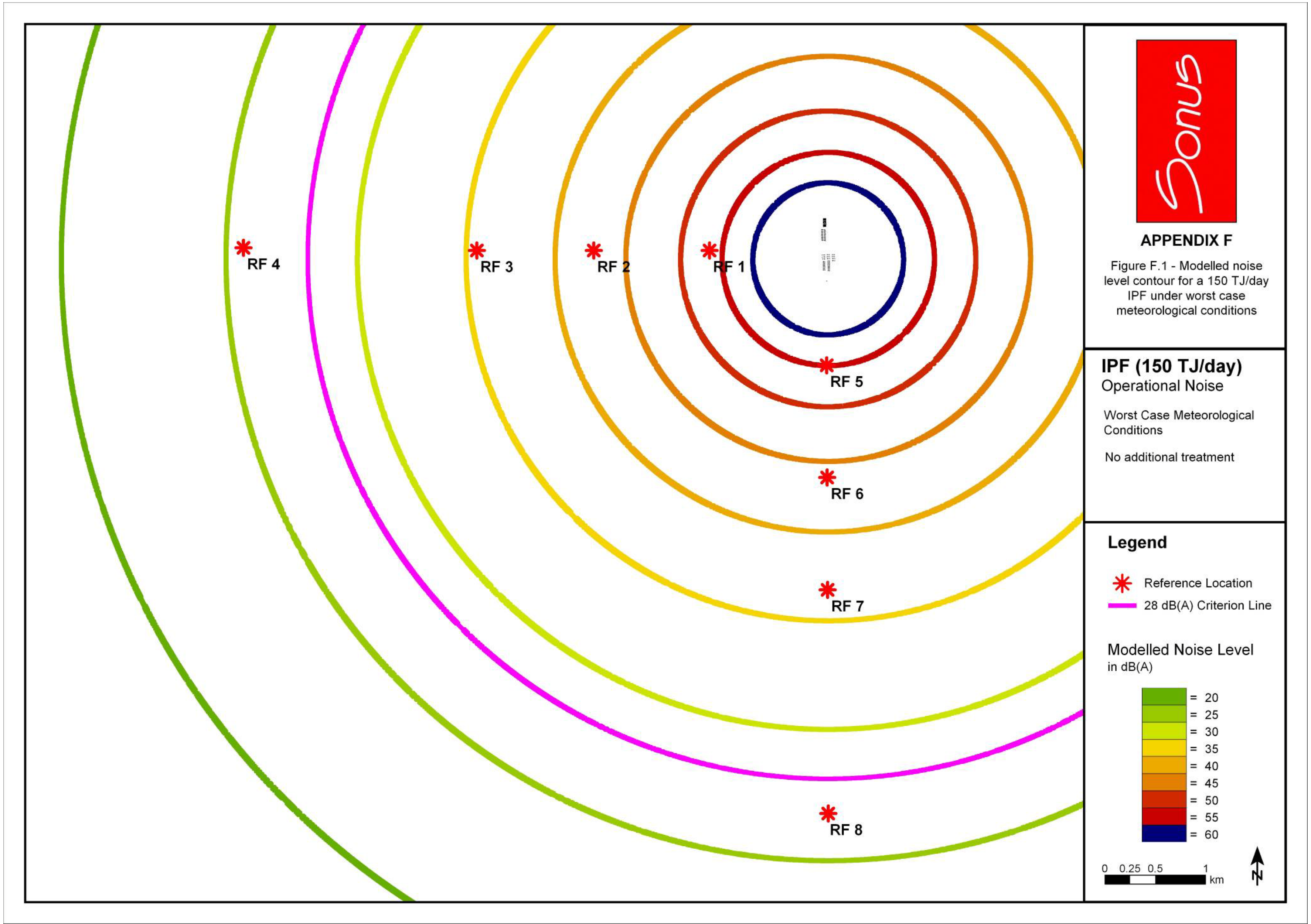
Table E.1: Sound power levels of the main noise sources at the production facilities.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)									Total (dB(A))
	31.5	63	125	250	500	1000	2000	4000	8000	
Long Term Noise Sources										
First Stage Gas Compression Unit										
Screw compressor	98	95	100	101	99	103	119	107	98	113
Electric motor - 2000hp	92	94	96	97	97	97	102	92	85	105
Cooler (2 fans, inlet plus outlet)	112	113	112	109	104	101	94	90	84	106
Further Stages Gas Compression Unit										
Reciprocating compressor	110	106	111	110	108	111	116	113	106	120
Electric motor - 5500hp	95	97	99	100	100	103	103	95	88	108
Cooler (3 fans, inlet plus outlet)	115	116	115	112	107	104	97	93	87	109
Power Generation Plant										
Power generator - 3.5 kW	74	74	77	79	82	82	81	76	68	87
Gas engine - exhaust with manufacturer installed silencer	77	84	88	72	69	73	78	79	68	84
Gas engine - air intake	88	95	101	99	94	93	92	94	95	101
Water Treatment Facility										
Centrifugal pump	74	74	77	79	82	82	81	76	68	87
Electric motor - 55 kW	74	74	77	79	82	82	81	76	68	87
Electric motor - 450 kW	82	84	86	88	90	90	90	86	81	95
Water Transfer Pump										
Centrifugal pump – 150 kW	75	75	88	93	94	95	89	83	75	98
Flare										
Normal operation – 0.02 TJ/d	78	78	79	80	82	83	85	90	85	93
Short Term Noise Sources										
Flare										
Maximum flow – 60TJ/d	102	105	110	105	95	90	95	105	100	107
Maximum flow – 150TJ/d	105	108	113	108	98	93	98	108	103	110

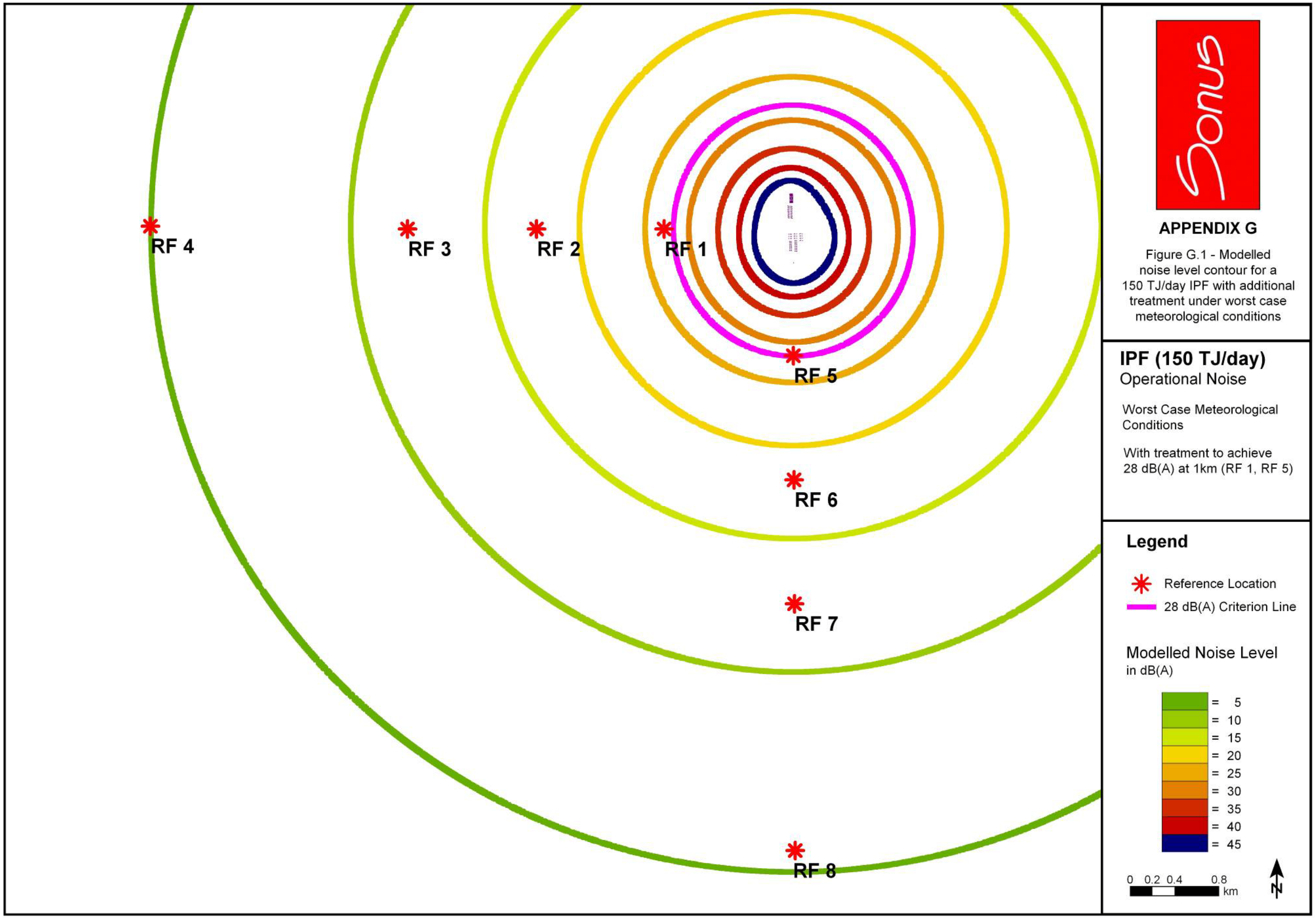
Table E.2: Sound power levels of the main noise sources at the production wells.

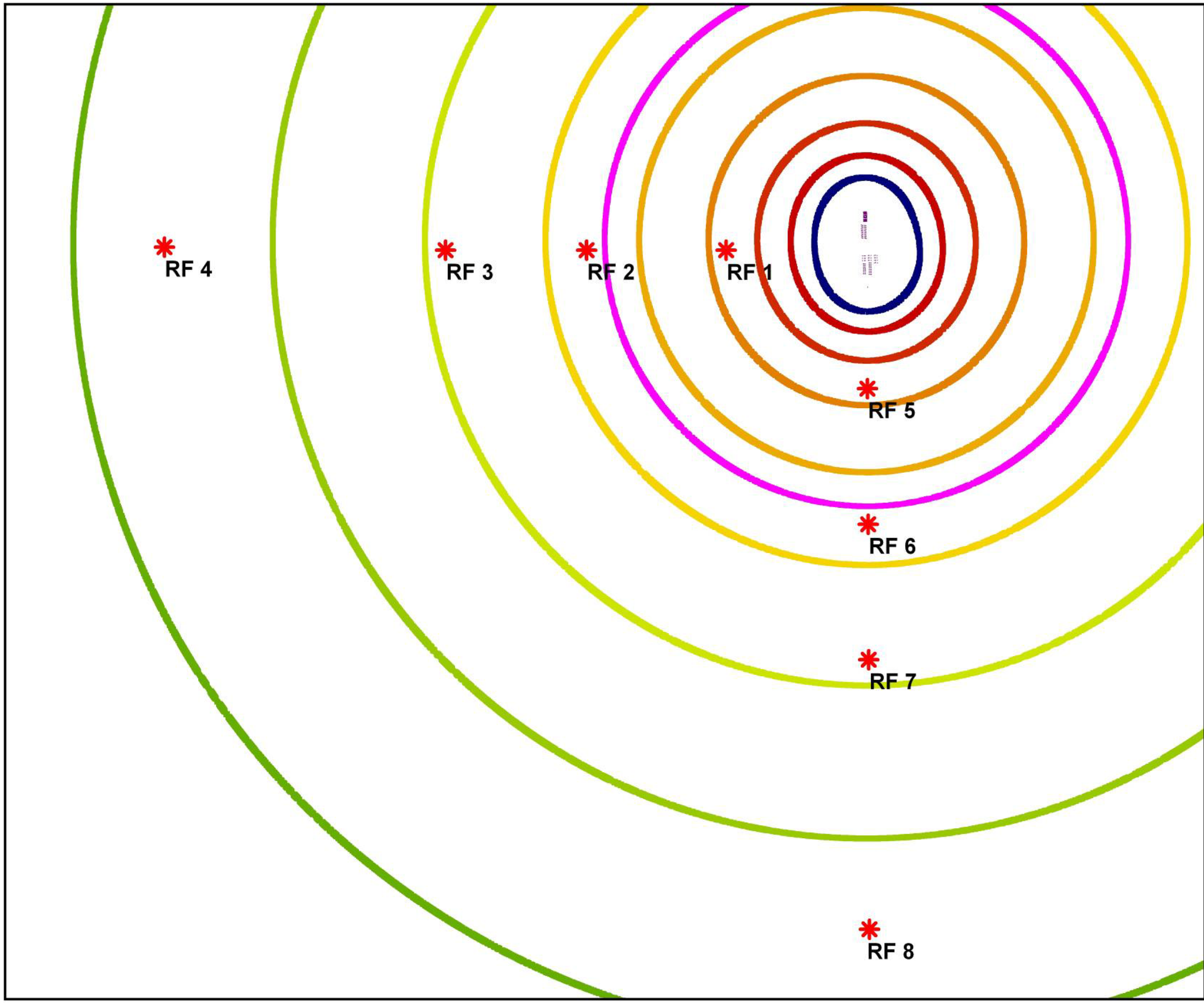
Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)									Total (dB(A))
	31.5	63	125	250	500	1000	2000	4000	8000	
Reference Case										
5.7L –V8 gas engine, 60kW motor	111	102	99	98	83	82	73	69	76	86
Alternative Option										
60kW motor (electricity obtained from main power grid)	89	79	75	80	70	70	74	74	77	81

APPENDIX F: NOISE CONTOUR – WITHOUT ADDITIONAL ACOUSTIC TREATMENT


RF 1
RF 2
RF 3
RF 4
RF 5
RF 6
RF 7
RF 8
APPENDIX F
Figure F.1 - Modelled noise level contour for a 150 TJ/day IPF under worst case meteorological conditions
IPF (150 TJ/day)
Operational Noise
Worst Case Meteorological Conditions
No additional treatment
Legend
Reference Location
28 dB(A) Criterion Line
Modelled Noise Level
in dB(A)
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
= 60
0 0.25 0.5 1
km
N

APPENDIX G: NOISE CONTOURS – WITH ADDITIONAL ACOUSTIC TREATMENT


RF 4
RF 3
RF 2
RF 1
RF 5
RF 6
RF 7
RF 8
APPENDIX G
Figure G.1 - Modelled noise level contour for a 150 TJ/day IPF with additional treatment under worst case meteorological conditions
IPF (150 TJ/day)
Operational Noise
Worst Case Meteorological Conditions
With treatment to achieve 28 dB(A) at 1km (RF 1, RF 5)
Legend
Reference Location
28 dB(A) Criterion Line
Modelled Noise Level
in dB(A)
= 5
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
0 0.2 0.4 0.8
km
N



Sonus

APPENDIX G

Figure G.2 - Modelled noise level contour for a 150 TJ/day IPF with additional treatment under worst case meteorological conditions

IPF (150 TJ/day)
Operational Noise

Worst Case Meteorological Conditions

With treatment to achieve 28 dB(A) at 2km (RF 2, RF 6)

Legend

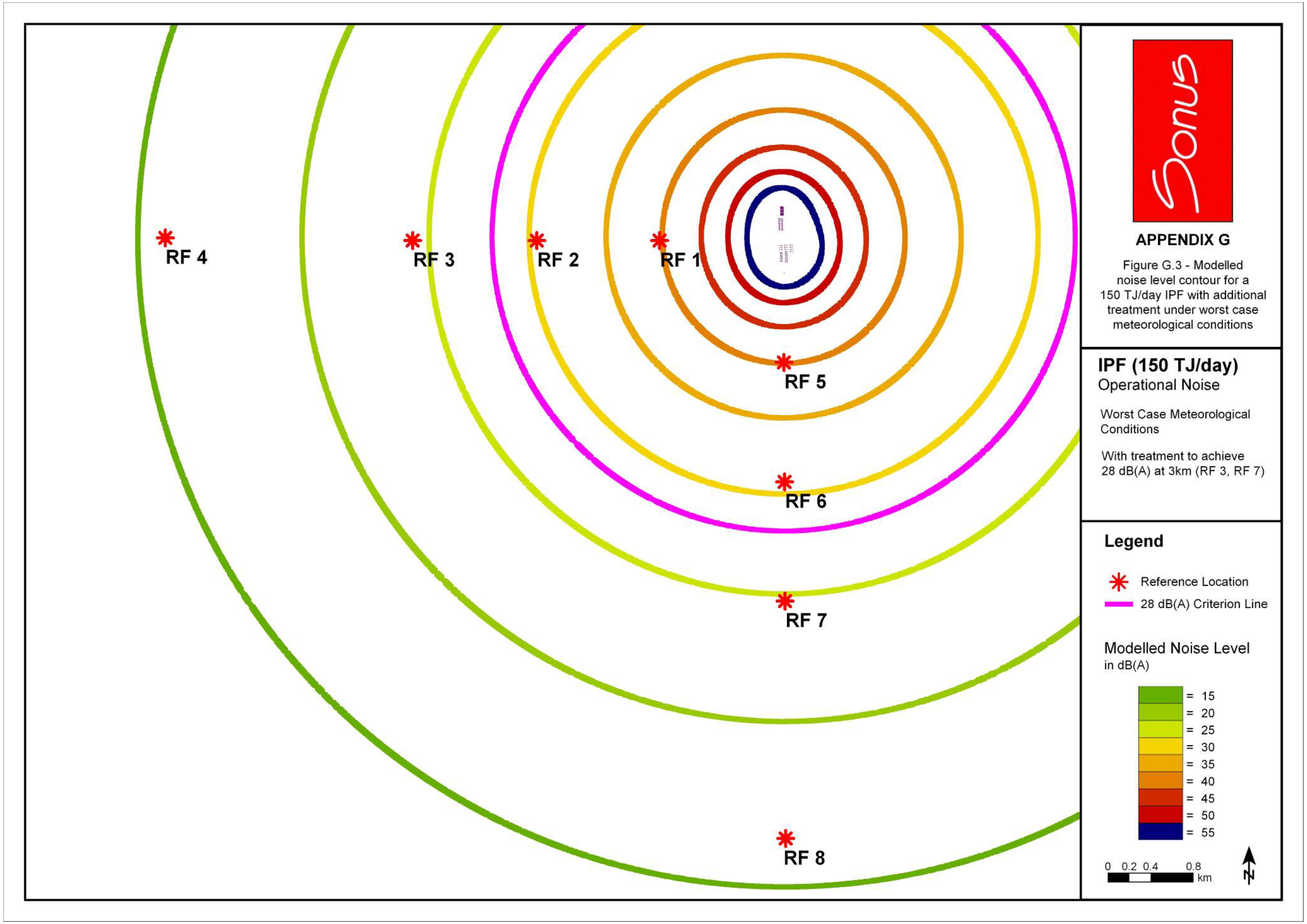
Reference Location
28 dB(A) Criterion Line

Modelled Noise Level
in dB(A)

= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50

0 0.2 0.4 0.8 km

N


RF 4
RF 3
RF 2
RF 1
RF 5
RF 6
RF 7
RF 8
Sonus
APPENDIX G
Figure G.3 - Modelled noise level contour for a 150 TJ/day IPF with additional treatment under worst case meteorological conditions
IPF (150 TJ/day)
Operational Noise
Worst Case Meteorological Conditions
With treatment to achieve 28 dB(A) at 3km (RF 3, RF 7)
Legend
Reference Location
28 dB(A) Criterion Line
Modelled Noise Level
in dB(A)
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
= 55
0 0.2 0.4 0.8
km
N