# Australia Pacific LNG Project

## Volume 5: Attachments

## Attachment 32: Noise and Vibration Impact Study – Gas Fields

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# Australia Pacific LNG Project
# Gas Fields
# Noise and Vibration Impact Study

## Document No. S851.2, Revision 1

Prepared for:

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# Contents

# 1.0 Introduction

Savery & Associates Pty Ltd was commissioned by WorleyParsons to prepare a report on potential noise and vibration impacts of the proposed Australia Pacific LNG 'Walloons' coal seam gas (CSG) fields development. The location of these gas fields is shown schematically in Figure 1.

The analysis of impacts was based on data supplied by Australia Pacific LNG Pty Limited (Australia Pacific LNG), and information obtained from field investigations of noise emissions associated with existing CSG drilling operations and CSG production infrastructure in the Spring Gully CSG production area in western Queensland.

The report addresses the requirements for noise and vibration assessment set down in the Terms of Reference for the Australia Pacific LNG Project Environmental Impact Statement (EIS). The exception is the consideration of potential noise and vibration impacts on fauna, which is addressed in the terrestrial ecology and impact assessment report.

The report summarises the investigations that have been conducted to:

- quantify baseline ambient noise levels and describe the acoustic environmental values in the project area
- sample noise emissions from CSG production infrastructure similar to that proposed
- assess the impact of CSG production infrastructure based on applicable Queensland noise regulations and guidelines, and
- assess the cumulative noise impacts of gas production infrastructure considering noise emissions from existing and approved Australia Pacific LNG and other CSG producer facilities.

The critical noise issues in relation to project approvals relate to:

- noise impacts associated with the construction of gas production wells
- noise impacts of operational gas processing facilities (GPFs) and the associated network of gas wells.

Significant vibration impacts are generally not anticipated associated with the construction or operational phase of the project. The possibility of construction vibration is considered in the context of possible blasting associated with pipeline construction in rocky areas.

## 2.0 Baseline survey

### 2.1 Site selection

Selection of noise monitoring sites was undertaken in consultation with Origin Energy, WorleyParsons and Geographical Information Systems personnel.

Residences selected for monitoring were considered to represent the range of typical noise sensitive sites within the Walloons gas fields' area. The location of development areas and identified monitoring sites are shown on Figure 1. Sensitive receptors within these areas are generally rural residential locations remote from major roadways, industrial facilities and urban infrastructure.

As the number of possible sensitive receptors (dwellings) within the study area is much larger than the number of sites that could practicably be included in an ambient noise monitoring programme, sites were selected that were considered typical of remote rural residential locations.

The sites selected were within the vicinity of proposed gas processing facilities. Not all sites were available due to limitations on land access at the time. A total of 25 sites were monitored (see Table 1).

For a given property, the following criteria were used to select the physical location of the noise logger:

- requirement that instrumentation be separated from livestock to prevent accidental damage to equipment
- attainment of maximum practicable separation of instrumentation from steady sources of noise that should not[1] be regarded as normal features of the ambient noise environment (e.g. at a residential location this included air-conditioning units, pool pump, septic pump and radio noise)
- attainment of maximum practicable separation from nearby vegetation
- the express wishes of the landowner for the monitoring site location, based on their understanding of the required monitoring site and their individual constraints.

Some logger sites were located adjoining private driveways; however the short duration of driveway vehicle pass-by events relative to the seven day rating background level (RBL) assessment period would not have affected the RBLs.

The baseline monitoring sites are summarised in Table 1 and shown on Figure 1. Details of instrumentation, reference weather station locations and photographic records of instrument locations are provided in the referenced appendices.

**Table 1 Summary of noise monitoring sites**

| Measurement location | Local Environs | Relevant gas field | GPS Coordinates Northing & Easting | Appendix file reference |
|---|---|---|---|---|

[1] As per advice in the Queensland DERM Noise Measurement Manual

| Measurement location | Local Environs | Relevant gas field | GPS Coordinates Northing & Easting | | Appendix file reference |
|---|---|---|---|---|---|
| Site 1 – "Waverley" | dwelling yard | Combabula/Ramyard | -26.3678 | 149.2339 | 1 |
| Site 2 – "Hillside" | dwelling yard | Combabula/Ramyard | -26.2404 | 149.3596 | 2 |
| Site 3 – "Waipiro" | dwelling yard | Combabula/Ramyard | -26.3237 | 149.291 | 3 |
| Site 4 – "Nullin" | dwelling yard | Combabula/Ramyard | -26.2740 | 149.5362 | 4 |
| Site 5 – "Seaside" | dwelling yard | Combabula/Ramyard | -26.4029 | 149.4364 | 5 |
| Site 6a – "Woodview" | open paddock | Combabula/Ramyard | -26.4094 | 149.7085 | 6 |
| Site 6b – "Cypress Downs" | dwelling yard | Combabula/Ramyard | -26.4559 | 149.6196 | 7 |
| Site 7 – "Kamilaroi" | dwelling yard | Carinya | -26.5084 | 149.6421 | 8 |
| Site 8 – "Dulacca North Rd" | open paddock | Carinya | -26.583 | 149.7317 | 8 |
| Site 9 – "Ellerslie" | dwelling yard | Carinya | -26.7105 | 149.7455 | 9 |
| Site 10 – "Sandlewood Grove" | dwelling yard | Carinya | -26.6775 | 149.9985 | 10 |
| Site 11 – "Devoncourt" | dwelling yard | Carinya | -26.5664 | 149.8752 | 11 |
| Site 12 – "Woodlands" | dwelling yard | Woleebee | -26.3678 | 149.8848 | 12 |
| Site 13b – "The Pines" | dwelling yard | Dalwogan | -26.7133 | 150.1092 | 13 |
| Site 13c –Middle Creek Rd | dwelling yard | Woleebee | -26.1064 | 150.0200 | 14 |
| Site 14 – "4 Mile Homestead" | dwelling yard | Dalwogan | -26.609 | 150.1599 | 15 |

| Measurement location | Local Environs | Relevant gas field | GPS Coordinates Northing & Easting | | Appendix file reference |
|---|---|---|---|---|---|
| | | | 7 | | |
| Site 16 – "Stoorallyn" | dwelling yard | Condabri | -26.7985 | 150.1672 | 16 |
| Site 19 – "Drildool" | dwelling yard | Condabri | -27.0583 | 150.3059 | 17 |
| Site 20 – "Haywen" | open paddock | Talinga/Orana | -26.9555 | 150.5061 | 18 |
| Site 21 – 1389 Tara-Chinchilla Rd | dwelling yard | Talinga/Orana | -26.8184 | 150.5340 | 19 |
| Site 22 – "Gavindale" | paddock | Talinga/Orana | -26.7428 | 150.4183 | 20 |
| Site 23b – Tara-Kogan Road | road reserve | Kianama | -27.0685 | 150.7459 | 21 |
| Site 24 – "The Meadows" | dwelling yard | Gilbert Gully | -27.6467 | 150.9096 | 22 |
| Site 27 – 92 Bark Road | dwelling yard | Gilbert Gully | -27.9116 | 150.9334 | 23 |
| Site 28 – "Western Creek" | dwelling yard | Gilbert Gully | -27.8297 | 151.0865 | 24 |

## 2.2 Noise monitoring procedures

Noise monitoring was conducted with reference to the following standards and procedures:

- Australian Standard AS1055.1-1997 Acoustics – Description and measurement of environmental noise, Part 1: General procedures
- Queensland Environmental Protection Agency (EPA) 'Noise measurement manual (3rd Edition, 1 March 2000)'.

The minimum monitoring duration of seven days at each location was selected to enable determination of the RBLs in accordance with the methodology set-out in the Department of Environment and Resource Management (DERM) 'Guideline, Planning for noise control'.

### 2.3 Noise monitoring instrumentation

Baseline noise monitoring was conducted utilising CESVA SC310 Type 1 one-third octave logging sound analyser and CESVA TK1000 outdoor microphone assembly at 1.5m microphone height.

Two types of microphone pre-amplifier combinations were used with the CESVA SC310 analyser; each has slightly different noise floor characteristics, as follows:

- CESVA C130 microphone with PA13 pre-amplifier – 18dBA system self-noise
- CESVA C250 microphone with PA14 pre-amplifier – 15dBA system self-noise.

An example of this instrumentation is illustrated in Figure 2.

Logger sampling was conducted at one-second intervals in frequency bands from 20Hz to 10kHz. The data was post-processed to obtain statistical parameters such as $L_{A10}$ and $L_{A90}$ at 15 minute intervals[2].

Instrumentation was field-calibrated prior to and following measurements with all post-calibration results within 0.4dBA of the pre-calibration level of 94.0dBA.

### 2.4 Meteorological monitoring instrumentation

Simultaneous monitoring of wind-speed, direction, temperature, pressure and humidity conditions was conducted in the vicinity of baseline noise monitoring locations, in accordance with the requirements of Australian Standard AS1055: Acoustics – Description and measurement of environmental noise, Part 1: General procedures. The instrumentation sampled the meteorological parameters at two-second intervals and produced summary information for 15 minute intervals that corresponded to the noise monitoring intervals. Sensors were located at a 3m reference height. The meteorological monitoring sites are indicated on Figure 1.

[2] See Appendix B glossary for explanation of acoustic terminology.

# 3.0 Analysis of baseline records

## 3.1 Adjustment for instrumentation noise floor

The RBLs are approaching or below the electronic self-noise of the noise logger instrument in the majority of data sets obtained for the project. It is necessary to deduct the self-noise of the instrument from the 'apparent' measured background level to determine the actual background noise level.

For example, if an apparent night-time RBL of 16dBA was measured utilising an instrument with a 15dBA self-noise specification, the true background level would be 9dBA after subtracting the self-noise component. True background noise levels that are below the most sensitive instrument noise floor of 15dBA are reported as <15dBA.

The resulting noise-floor-adjusted RBLs and minimum equivalent hourly noise levels are presented in Sections 3.3 and 3.4. The 'raw' data, together with the apparent instrument noise floors are presented in the Appendices 2-25.

## 3.2 Seasonal insect noise

The EPA Noise measurement manual indicates that the influence of insect noise on baseline noise levels should be carefully considered, to ensure that sampling during warmer months, which may include significant insect noise contribution to $L_{A90}$ levels[3], is not inadvertently used to represent baseline conditions at other times of the year when insect noise may be less significant (Caley & Savery 2007[4]). Significant insect noise is usually absent at night in western Queensland during dry winter months.

One-third octave spectral baseline logging was conducted in the frequency range of 20 hertz (Hz) to 10 kilo-hertz (kHz) to enable the identification of seasonal or episodic insect and frog noise. The presence (or absence) of such noise was determined from inspection of the spectrogram for the noise-monitoring period. The spectrogram is a graphical plot of sound pressure level, represented by colour, versus frequency (y-axis) and time (x-axis). Typically, insect activity may be identified as a constant contribution in one or more one-third-octave bands above 2kHz.

If significant evening or night-time insect noise is detected, this noise is filtered by post-processing the measurement data prior to calculation of the aggregate background noise levels for day, evening and night-time periods. Both the filtered and unfiltered aggregate background noise levels are reported.

Baseline sampling was conducted in winter months between 10 June and 9 July 2009, excepting Site 23b which was monitored between 10 and 17 September 2009. Although some insect noise was evident on dusk at a number of monitoring sites, it was not found to be a persistent night-time feature at any site and did not significantly influence RBLs at any site.

[3] See glossary for explanation of acoustic terminology
[4] Caley, M. & Savery, J. 2007 *The Case for Spectral Baseline Noise Monitoring for Environmental Noise Assessment* 14th International Congress on Sound and Vibration, Cairns 2007

## 3.3 Meteorological conditions

Intervals with any precipitation or excessive wind speed (average wind-speeds above 5 metres per second (m/s)) were cross-referenced to the noise monitoring data and excluded from statistical summary data to the combined noise and weather data plots in the data found in the Appendices 1-24.

## 3.4 Rating background noise levels

The RBLs as determined in accordance with the DERM Guideline, 'Planning for noise control' (DERM Guideline) are presented in Table 2.

The results indicate that across the study area, background levels are consistently very low, with evening and night-time RBLs typically at or below 15dBA. Only sites close (i.e. within 1km) to major highway routes will have higher night time RBLs (up to 18dBA).

Sites with recorded night RBLs above 15dBA can be explained by proximity to known noise sources as follows:

- Site 4 was elevated, with an operational drill rig observed a few kilometres to the south-east near to the Yuleba-Taroom Road. RBLs would normally be expected to be below 15dBA in the absence of this noise influence.
- Site 10 was exposed to noise from a domestic water feature that was found to run continuously over the full sampling period. RBLs would normally be expected to be at or below 15dBA, based on the records from the nearest sites of 9 and 13b.
- Site 14 was both located within 1km of the Leichhardt Highway, which carries a significant number of heavy vehicles; for each pass-by event noise levels above 15dBA were generated for a significant period of time.
- Site 16 was within 500m of the Leichhardt Highway, with slightly higher RBLs than site 14, also as a consequence of sustained noise from pass-by events.
- Site 21 was within 70m of the Chinchilla-Tara Road.
- Site 23 was within 100m of the Tara-Kogan Road.
- Site 27 was located near a battery room for a photovoltaic solar power installation. Low levels of steady and cyclic inverter-related noise appear to have elevated background noise levels. RBLs would normally be expected to be below 15dBA at this location, based on the RBLs recorded at sites 24 and 28.

Daytime RBLs show greater variability than at night due to the varying proximity of instrumentation to vegetation and at some sites, proximity to stock and transportation routes. Noise from vegetation normally follows a diurnal cycle associated with daytime breezes and still conditions at night.

**Table 2: Rating background levels**[5]

| Measurement Location | Rating background level (min$L_{A90}$ – dBA) | | |
|---|---|---|---|
| | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
| Site 1 – "Waverly" | 21 | <15 | <15 |
| Site 2 – "Hillside" | 20 | <15 | <15 |
| Site 3 – "Waipiro" | 20 | <15 | <15 |
| Site 4 – "Nullin" | 22 | 16 | 16 |
| Site 5 – "Seaside" | 16 | <15 | <15 |
| Site 6a – "Woodview" | 17 | <15 | <15 |
| Site 6b – "Cypress Downs" | 25 | <15 | <15 |
| Site 7 – "Kamilaroi" | 20 | <15 | <15 |
| Site 8 – "Dulacca North Road" | 19 | <15 | <15 |
| Site 9 – "Ellerslie" | 20 | <15 | <15 |
| Site 10 – "Sandlewood Grove" | 33 | 33 | 33[6] |
| Site 11 – "Devoncourt" | 27 | 16 | <15 |
| Site 12 – "Woodlands" | 25 | <15 | <15 |
| Site 13b – "The Pines" | 22 | 15 | 15 |
| Site 13c –Middle Creek Rd | 23 | 17 | <15 |
| Site 14 – "4 Mile Homestead" | 27 | 17 | 16 |
| Site 16 – "Stoorallyn" | 28 | 20 | 18 |
| Site 19 – "Drildool" | 25 | <15 | <15 |
| Site 20 – "Haywen" | 20 | <15 | <15 |
| Site 21 – 1389 Tara-Chinchilla Rd | 30 | 20 | 18 |
| Site 22 – "Gavindale" | 23 | <15 | <15 |
| Site 23 – Tara-Kogan Road | 29 | 17 | 16 |
| Site 24 – "The Meadows" | 22 | <15 | <15 |
| Site 27 – 92 Bark Road | 23 | 22 | 21 |
| Site 28 – "Western Creek" | 23 | <15 | <15 |

## 3.5 Minimum equivalent hourly noise levels

A summary of the minimum $L_{Aeq,1hour}$ data for the day, evening and night periods for each monitoring is presented in Table 3.

**Table 3: Minimum equivalent levels**[7]

| Measurement Location | Minimum Equivalent Level (min$L_{Aeq,1hour}$ – dBA) |
|---|---|

[5] Corrected for instrumentation noise floor
[6] Background levels for the day evening and night periods were contaminated by water-feature noise.
[7] Corrected for instrumentation noise floor

| | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
|---|---|---|---|
| Site 1 – "Waverly" | 37 | 30 | <15 |
| Site 2 – "Hillside" | 35 | 24 | 18 |
| Site 3 – "Waipiro" | 36 | 28 | 15 |
| Site 4 – "Nullin" | 39 | 22 | 20 |
| Site 5 – "Seaside" | 35 | 18 | 15 |
| Site 6a – "Woodview" | 33 | 17 | 15 |
| Site 6b – "Cypress Downs" | 39 | 19 | 16 |
| Site 7 – "Kamilaroi" | 37 | 27 | <15 |
| Site 8 – "Dulacca North Road" | 33 | 20 | 18 |
| Site 9 – "Ellerslie" | 35 | 21 | 16 |
| Site 10 "Sandlewood Grove" | 41 | 38 | 36[8] |
| Site 11 – "Devoncourt" | 41 | 24 | 22 |
| Site 12 – "Woodlands" | 42 | 27 | 21 |
| Site 13b – "The Pines" | 43 | 22 | 19 |
| Site 13c –Middle Creek Rd | 38 | 27 | 18 |
| Site 14 – "4 Mile Homestead" | 38 | 35 | 27 |
| Site 16 – "Stoorallyn" | 41 | 37 | 30 |
| Site 19 – "Drildool" | 35 | 28 | 21 |
| Site 20 – "Haywen" | 33 | 28 | 24 |
| Site 21 – 1389 Tara-Chinchilla Rd | 50 | 43 | 25 |
| Site 22 – "Gavindale" | 37 | 21 | 17 |
| Site 23 – Tara-Kogan Road | 43 | 30 | 23 |
| Site 24 – "The Meadows" | 38 | 25 | 17 |
| Site 27 – 92 Bark Road | 30 | 27 | 25 |
| Site 28 – "Western Creek" | 42 | 28 | 22 |

## 3.6 Ambient vibration levels

Ambient vibration levels are generally not significant in the study vicinity. The exception is close to heavy vehicle road corridors that contain pot-holes or other significant surface irregularities. This situation may produce perceptible transient

[8] Day, evening and night levels were dominated by noise from a nearby water feature

vibration levels during heavy vehicle pass-by in dwellings located at minimum road set-back distances. Well formed and sealed roads are not a significant source of ambient vibration at habitable distances from roadways.

### 3.7 Summary results

In general, the baseline results show that the acoustic environment during winter months is relatively quiet at all times of the day or night, except for bird calls at dawn and dusk, rustling vegetation in response to winds, and the intermittent sound of passing vehicles at locations within 'earshot' of major roadways. Night-time background noise levels were consistently below the 15dBA detection threshold of the monitoring instrumentation, with the exception of monitoring sites relatively close (less than 1000m) to major roadways.

During the warmer months, ambient acoustic environment often contains significant sustained insect noise from cicadas and crickets. Insect noise levels also often increase following rainfall, temporarily increasing background noise levels.

For the purpose of minimising potential noise impacts on a year-round basis, including winter times when insect noise is minimal, noise criteria should be determined from background noise monitoring results that are free of significant insect noise contributions. The data that has been gathered for this project is therefore suitable for this purpose.

Baseline vibration levels are not significant.

# 4.0 Assessment criteria

## 4.1 Environmental values to be protected

The Queensland Environmental Protection (Noise) Policy 2008 (EPP Noise) broadly identifies the environmental values to be enhanced or protected within the state of Queensland as:

- the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems
- the qualities of the acoustic environment that are conducive to human health and wellbeing, including 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
- the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

The study focus is on individuals and residences rather than businesses due to the rural nature of the region.

## 4.2 Construction noise goals

The following sections provide recommended noise criteria for management of construction noise from activities that are.

### 4.2.1 Standard daytime construction hours

Local government may gazette local laws to manage environmental nuisance, including construction noise, under the Queensland *Environmental Protection Act 1994* (EP Act).

However, if specific local laws are not enacted to manage construction noise (as is the case throughout the study area), and if the construction activity is not subject to an existing environmental authority (EA)[9] , the Division 3 default noise standard – section 440R Building work – of the EP Act would apply, as per the following extract:

*"440R Building work*

*(1) A person must not carry out building work in a way that makes an audible noise*

*(a) on a business day or Saturday, before 6:30am or after 6:30pm; or*

*(b) on any other day, at any time."*

There are currently no noise limits or guidelines[10] applicable to construction noise within the nominal regulated construction hours of 6.30am to 6.30pm business days and Saturdays, as defined in the EP Act. However, the Act does provide a

[9] For example, well-drilling noise would be subject to existing EA noise conditions on some tenements

[10] The former Department of Environment and Heritage E1 Guideline for construction noise was formally withdrawn and has not been replaced.

mechanism for controlling unreasonable construction noise in the event that a noise complaint is investigated and validated by an authorised officer.

### 4.2.2 Other times of the day or night

Currently, there is no Queensland guideline that addresses construction noise outside standard hours and at night.

The EPP Noise defines 'Acoustic quality objectives' for the environment that are conducive to human health and wellbeing, including the ability for individuals to sleep, study, relax or converse. The key acoustic quality objectives relevant to residential locations are reproduced below in Table 4. Whilst not intended for setting noise limits for permanent noise sources, these objectives may be used for assessing evening or night-time construction noise.

**Table 4: EPP Noise Acoustic quality objectives for residential dwellings**

**Schedule 1 Acoustic quality objectives**

section 8

| Column 1 | Column 2 | Column 3 | | | Column 4 |
|---|---|---|---|---|---|
| Sensitive receptor | Time of day | Acoustic quality objectives (measured at the receptor) *dB(A)* | | | Environmental value |
| | | $L_{Aeq,adj,1hr}$ | $L_{A10,adj,1hr}$ | $L_{A1,adj,1hr}$ | |
| dwelling (for outdoors) | daytime and evening | 50 | 55 | 65 | health and wellbeing |
| dwelling (for indoors) | daytime and evening | 35 | 40 | 45 | health and wellbeing |
| | night-time | 30 | 35 | 40 | health and wellbeing, in relation to the ability to sleep |

The measurement parameters for the acoustic quality objectives ($L_{Aeq,adj,1hr}$ $L_{A10,adj,1hr}$ $L_{A1,adj,1hr}$) include an adjustment (designated by the 'adj' subscript) for tonal and/or impulsive characteristics of the noise under investigation that may increase the subjective loudness of a noise. The required adjustment for tonal and/or impulsive characteristics is the sum of correction factors $K_1$ and $K_2$, summarised in Table 5 in accordance with AS1055 Acoustics –Description and measurement of environmental noise Part 1: General procedures.

**Table 5: Adjustments for audible characteristics 'adj' = K1 + K2**

| Audible characteristic | Criterion | Correction |
|---|---|---|
| Tonality | Subjectively just detectable | K1 = 2-3dB |
| | Subjectively prominent (clearly audible)[11] | K1 = 5-6 dB |
| Impulsivity | Subjectively detectable[12] | K2 = 2dB |

The EPP Noise defines the relevant night-time acoustic quality objectives internal to a dwelling for residential receptors. Without specific knowledge of the orientation of a dwelling relative to a noise source, the type of windows or the degree of window opening the indoor objectives of 30dBA $L_{Aeq,adj,1hr}$ and 40dBA $L_{A1,adj,1hr}$ can be translated to outdoor objectives by accounting for a nominal 10dBA reduction through the building facade.

The resulting equivalent outdoor noise criteria relevant to assessment of temporary night-time construction noise are 40dBA $L_{Aeq,adj,1hr}$ and 50dBA $L_{A1,adj,1hr}$.

It is noted, however, that the DERM advice on noise criteria for prevention of sleep disturbance results in an outdoor $L_{Amax}$ criterion of 47dBA (refer Section 4.3.3). It is therefore recommended that 50dBA $L_{A1,adj,1hour}$ acoustic quality objective be replaced with the sleep disturbance criterion of $L_{Amax}$ 47dBA. This level is not adjusted for tonal or impulsive characteristics.

Noise measurement experience around construction sites generally indicates that construction noise attracts a tonal and/or impulse noise characteristic adjustment of 5dBA.

The recommended construction noise criteria for night-time construction activities are therefore 35dBA $L_{Aeq,1hr}$ and 47dBA $L_{Amax}$.

## 4.3 Operational noise limits

DERM advises that noise emission limits for new major industrial noise sources should be determined utilising the Guideline to protect acoustic environmental values.

The Guideline preamble indicates it is intended to manage three aspects of the acoustic environment that may be affected by new industrial development, commercial premises and mining operations:

- the control and prevention of 'background noise creep' (the gradual cumulative increase in minimum noise levels generated by continuously operating machinery)
- the containment of variable noise levels and short term noise events to an 'acceptable level' above the background noise levels (for example, noise associated with a short term but periodic noise such as a process pressure relief valve)

[11] The objective test of tonality is as per AS1055.1 Clause 6.6.3

[12] The objective test of impulsive characteristics is as per AS1055.1 Clause 6.6.4

- the setting of noise limits for transient noise events to avoid 'sleep disturbance' (for example, a temporary release of compressed air or a process alarm) as outlined in Section 4.3.3.

### 4.3.1 Design planning noise levels

Background noise levels at night are generally lower than other times, therefore impacts associated with continuously operating noise sources are assessed using night time noise criteria. Key sources include GPFs, WTFs, and gas well drives.

The baseline noise monitoring conducted across 24 monitoring sites has demonstrated a high degree of consistency of rating background levels throughout the study area. The results can be simplified into sites near transportation corridors and sites remote from transportation corridors.

Accordingly the analysis of planning noise levels (PNLs), derived from measured rating background levels, is presented for two simplified classifications of all baseline records, based on the night RBL and observed proximity to significant road transport corridors as follows:

- Night RBL < 15dBA (sites remote from significant transport corridors)
- Night RBL = 16dBA (sites within 1000m of significant transport corridors)

The guideline recommends a PNL for a new facility expressed as an unadjusted equivalent continuous A-weighted sound pressure level ($L_{Aeq\ 1\ hour}$), with built-in penalties for assumed tonal and/or impulsive characteristics of a future noise source (or sources). However, as the adjustments for tonal and impulse noise characteristics cannot be anticipated in advance for all source/receiver situations, it is more appropriate that the PNLs are expressed as adjusted levels ($L_{Aeq\ 1\ hour,\ adj}$)[13]. The detailed derivation of the PNLs for this project is provided in Appendix A.

The resultant design PNLs for the project area are summarised in Table 6. The received noise level should be adjusted for tonal and/or impulsive characteristics when using these PNLs to assess the predicted noise at a residence from a specific noise source, as detailed in Table 7.

**Table 6: Design planning noise levels at residential receivers (outdoors)**

| Receiver areas | Design planning noise level ($L_{Aeq,1hour,adj}$ – dBA) | | |
|---|---|---|---|
| | Day (7am-6pm) | Evening (6pm-10pm) | Night (10pm-7am) |
| Residence with negligible transportation noise | 28 | 28 | 28 |
| Residences within 1km of major transportation corridor | 35 | 28 | 28 |

[13] On other projects, the presumption of a tonal correction in deriving the PNLs has caused confusion in the specification of licensed levels. It is more appropriate and accurate that the determination of adjustments for tonal and impulse corrections is performed when emissions from a specific source at a given distance are assessed.

### Table 7: Guideline corrections to design PNLs for audible characteristics

| Audible characteristic | Criterion | Correction |
|---|---|---|
| Tonality | Subjectively just detectable | K1 = 2 - 3dB |
| | Subjectively prominent (clearly audible)[14] | K1 = 5 - 6 dB |
| Impulsivity | Subjectively detectable[15] | K2 = 2 dB |

#### 4.3.2 Potential audibility of compliant new plant noise

Table 8 presents a comparison of the measured RBLs for the representative study Sites 9 and 14 and the design PNLs from Table 6.

This comparison illustrates that the PNLs that have been determined in accordance with the Guideline are significantly higher than the RBLs.

This highlights the possibility that noise emissions from the CSG processing facilities, at levels that just comply with the Guideline, would be audible at residential locations when background noise levels are low.

### Table 8: Comparison of RBLs with design planning noise levels

| Receiver categories | Design planning noise level ($L_{Aeq,1hour,adj}$ – dBA) | | |
|---|---|---|---|
| | Day (7am-6pm) | Evening (6pm-10pm) | Night (10pm-7am) |
| negligible transportation noise | 28<br>(20 RBL) | 28<br>(<15 RBL) | 28<br>(<15 RBL) |
| within 1km of major transportation corridor | 35<br>(27 RBL) | 28<br>(17 RBL) | 28<br>(16 RBL) |

The degree to which the noise is likely to be audible would depend critically on the presence or absence of distinctive sound characteristics in the noise generated by new CSG plant, in addition to the overall sound pressure level. Characteristics such as whistles, whines, hums and throbbing may increase the subjective audibility of a source of noise above that indicated by the overall sound level.

The ideal noise characteristic for a mechanical source of noise is described as 'broad-band'. Examples of natural broad-band noise include the steady 'rushing' sound characteristic of rustling vegetation during a steady breeze or the sound of a distant waterfall. Common examples of human-made broad-band noise sources include pedestal fans, split-system indoor air-conditioning units or pool filtration systems that are free of discernible motor hum. The broad-band sound characteristic originates from random turbulence in air or water in all these natural and human-made examples.

[14] The objective test of tonality is as per AS1055.1 Clause 6.6.3

[15] The objective test of impulsive characteristics is as per AS1055.1 Clause 6.6.4

#### 4.3.3 Consideration of sleep disturbance from transient noise sources

The relationship between the level of a noise event external to a dwelling and sleep awakenings is dependent on many factors, including the sound pressure level, sound frequency, how rapidly the noise increases (i.e. impulsive sound versus a gradual increase), the familiarity of the noise to the individual, the frequency of events and individual sensitivity. The Guideline advises an approximate relationship between the maximum external noise event level ($LA_{msx}$), the degree of dwelling sound insulation and the resulting likelihood of sleep awakening as shown in Table 9.

The Guideline suggests achieving no higher than 10% probability of sleep awakenings. It is recommended that the nominal goal be reduced to 5% probability of sleep awakenings for the very low background noise environments encountered in the study area. Except were site-specific information is available, a nominal facade reduction of 10dB is recommended to account for the combined effects of building orientation and the possibility of windows being open. Thus the indicative limit on transient events for the project to prevent sleep awakenings is 47dBA (max $L_{Amax}$). This provides an upper noise limit relevant to short-term transient noise events.

Sleep disturbance would be unlikely at receptor locations for normal plant operations, as this limit is much higher than the night time planning noise levels.

**Table 9: Guideline probability of sleep awakening**

| Typical facade noise reduction (dBA) | Window description | External maximum instantaneous noise level ($L_{Amax}$, dBA) corresponding to awakening probability (%) | | | |
|---|---|---|---|---|---|
| | | 0% | 5% | 10% | 20% |
| 5 | Windows wide open | 37 | 42 | 47 | 52 |
| 10 | Windows partially closed | 42 | 47 | 52 | 57 |
| 20 | Single glazed, closed | 52 | 57 | 62 | 67 |
| 25 | Double glazed, closed | 57 | 62 | 67 | 72 |

#### 4.3.4 Low-frequency noise criteria

Low-frequency noise at frequencies of less than 20Hz, below the audible frequency range, is termed 'infra-sound'. At high intensities, sound in this frequency range can cause resonances of body cavities (for example, chest resonance at 10Hz) that have been linked to symptoms of un-wellness in some studies (Carrol et al 2004[16]).

Regulatory assessment criteria have not yet been developed in this area. However, manufacturers of gas turbines have been aware of the potential problem for some time and guidelines have been established to avoid air-borne low-frequency vibration effects. ANSI B133.8-1977[17] suggested a guideline of 75dBC to 80dBC[18] for turbine

[16] Carroll et al, 2004 'The health effects of environmental noise – other than hearing loss', Department of Health and Aging, Australia.
[17] ANSI B133.8-1977 (reaffirmed 1989) Gas Turbine Installation Sound Emissions, American National Standards, The American Society of Mechanical Engineers

exhaust noise to avoid sound-induced low-frequency vibration in buildings. Hessler 2004[19] has recommended a much lower criterion for turbine noise of 60dBC measured outdoors, for 'very quiet suburban or rural residential areas', with the additional condition that the difference between the A-weighted and C-weighted emissions should not be greater than 20dB.

A guideline level of 60dBC is recommended for this project. This will be relevant to the assessment of GPF noise only, for which fan-cooler noise could conceivably generate significant low-frequency noise.

## 4.4 Construction vibration criteria

### 4.4.1 Environmental values to be protected

Community concern about temporary construction vibration or blast vibration normally relates to the perceived possibility of cracking of, or structural damage to, valued property. Examples of valued property include dwelling, business premises, swimming pool or a significant masonry fence.

Less commonly, stakeholder concerns relate to the potential from construction activities to cause vibrations which disrupt vibration sensitive equipment associated with a business or hospital, livestock or cause distractions within an educational institution.

It is uncommon for construction vibration associated with earth moving or trenching activities to cause sleep disturbance or disturbance to relaxation, independent of concern or anxiety about perceived potential property damage. Similarly, there is no known adverse health effects associated with such construction vibration in the community (excluding direct occupational vibration impacts to employees that operate plant and equipment) other than concern or anxiety directly relating to perceived potential property damage.

The values to be protected in relation to vibration are therefore:-

- the 'peace of mind' that property is not at risk of damage
- the monetary value of properties and business processes, as may be affected by cosmetic/structural damage or interference to profitable processes or other valuable assets.

### 4.4.2 Blasting criteria

The EP Act defines acceptable levels of ground vibration and air-blast over-pressure for buildings in section 440ZB, as follows:

- airblast overpressure not to exceed 115dBZ for 4 out of 5 consecutive blasts with a maximum of 120dBZ Peak for any blast
- ground vibration not to exceed 25mm a second, peak particle velocity respectively, for vibrations of more than 35 Hz and 10mm a second for vibrations no more than 35 Hz.

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[18] The 'C' frequency weighting adjustments are much reduced at low frequencies compared to 'A' weighting, giving greater 'prominence' to the low-frequency components in the overall measured dBC sound pressure level compared to the measured dBA sound pressure level.

[19] Hessler, G.F., 2004 Proposed criteria in residential communities for low-frequency noise emissions from industrial sources, Journal of Noise Control Engineering 52(4), 2004

Appendix J of Australian Standard (AS) 2187.2-2006 'Explosives - Storage and use part 2: Use of explosives' provides detailed information about blast vibration and air-blast over-pressure estimation and control.

In regard to prevention of minor or cosmetic damage in structures, AS2187.2 refers directly to British Standard (BS)7385.2 1993 'Evaluation and measurement for vibration in buildings Part 2. Guide to damage levels from ground-borne vibration', for recommended maximum vibration levels. These recommendations are detailed in Section 4.4.3 for non-blast vibration sources.

### 4.4.3 Other sources of construction vibration

Significant ground-borne vibration may be experienced close to construction processes such as piling, vibratory rolling, tunnel-boring, excavation or rock-hammering.

British Standard BS 7385.2 provides guidance on vibration levels to prevent cosmetic vibration-induced damage to buildings due to a variety of sources.

The ground vibration guide values, recommended by BS 7385.2 for 'transient' vibration sources above which cosmetic damage could occur, are shown numerically and graphically in Table 10. It is recommended that the limits be halved for 'cyclic' vibration sources, which are more likely to generate an accumulated resonant vibration response within the structure being protected.

'Transient' vibration sources refers to sources of vibration where successive vibration impulses can be considered as separate disturbances with respect to the vibration response of the structure being protected. Examples of transient vibration sources include single drop-hammer-blows from impact piling (each impact separated by a number of seconds), the dropping of heavy objects, or irregular vibration from an excavator bucket stalling/releasing during digging through uneven ground.

'Cyclic' vibration refers to repetitive sources of vibration where evenly sequenced (periodic) vibration peaks produce an accumulated vibration response in the structure being protected. Cyclic sources include vibratory rolling, vibratory pile driving, rock-hammering, and rapid air-hammer impact piling.

**Table 10: BS 7385.2 Guide values for avoiding cosmetic building damage**

**Table 1. Transient vibration guide values for cosmetic damage**

| Line (see figure 1) | Type of building | Peak component particle velocity in frequency range of predominant pulse | |
|---|---|---|---|
| | | 4 Hz to 15 Hz | 15 Hz and above |
| 1 | Reinforced or framed structures<br>Industrial and heavy commercial buildings | 50 mm/s at 4 Hz and above | |
| 2 | Unreinforced or light framed structures<br>Residential or light commerical type buildings | 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz | 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above |

NOTE 1. Values referred to are at the base of the building (see 6.3).
NOTE 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

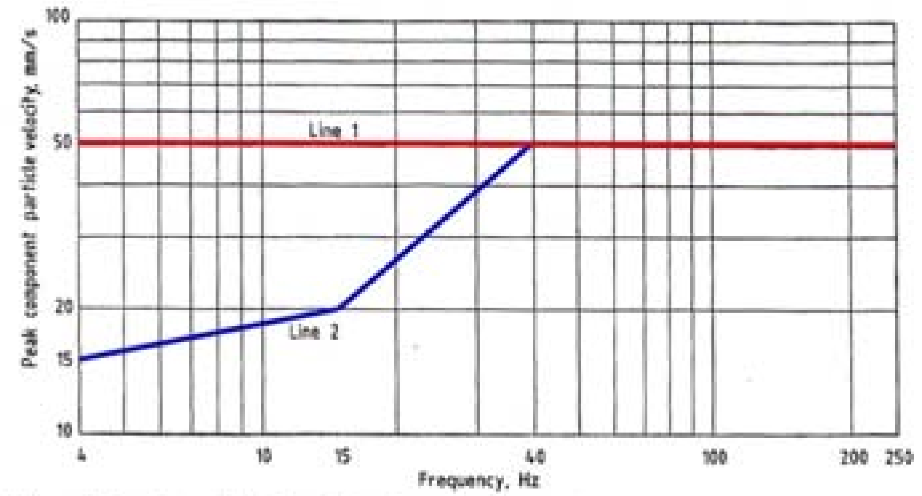



**Figure 1. Transient vibration guide values for cosmetic damage**

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 10, i.e. at peak component particle velocity of 100mm/s, or greater for a line 1 building (i.e. reinforced or framed structures, industrial and heavy commercial buildings).

Major damage to a building structure would be expected at ground vibration values greater than four times the values given in Table 10, i.e. at peak component particle velocity of 400mm/s, or greater for a line 1 building.

### 4.4.4 Criteria for protection of vibration sensitive property

The most common concern regarding the influence of construction vibration on sensitive processes relates to computer hard-drives. However with the advent of portable computing, computer drives are no longer particularly vibration sensitive. Vibration guidelines for protection of buildings against cosmetic damage are sufficient to protect desktop computers also.

Receptors that are highly sensitive to vibration are generally limited to major hospitals or precision manufacturing processes containing precision microscopes and medical scanning devices.

In some instances heritage-listed structures may also be deemed to be vibration-sensitive, however this should not be assumed. Specific vibration management plans are normally developed for each such facility or structure on a case-by-case basis.

Any construction blasting will be conducted to maintain a minimum 100m buffer from all identified heritage structures, in addition to site-specific adoption of appropriate vibration management goals.

## 5.0 Noise modelling methodology

An environmental noise model of nominal flat terrain gas field area was constructed using ISO 9613-2 (1996), Acoustics - Attenuation of sound during propagation outdoors, Part 2: General method of calculation, as implemented in SoundPLAN software. The method predicts A-weighted sound pressure levels under meteorological conditions favourable to sound propagation from noise sources (that is, mild temperature inversion with slight downwind). The overall model accuracy is estimated as ± 3dBA.

The graphical noise contours generated by the model represent the envelope of results for noise propagation in all directions (that is, summary of typical worst-case noise propagation in all directions).

Where predictions are presented in the form of distance versus level curves, the curves represent the predicted level in the down-wind direction.

The detailed calculation of sound propagation from the source to the receiver locations is calculated with specific algorithms for the following physical effects:

- geometrical divergence
- atmospheric absorption (in accordance with ISO 9613 Part 1)
- ground effect (hard ground reflects sound, soft ground absorbs sound)
- reflection from surfaces (typical 1dBA reflection loss for buildings)
- screening by obstacles (horizontal and vertical diffraction),
- dense vegetation (none included).

Noise contours were modelled 2m above local ground level.

The ground around GPF sites is assumed to be hard-packed and acoustically reflective. Otherwise, all terrain is assumed to be acoustically soft.

No allowance has been made for the effect of forested areas, as modelling for the EIS is based on possible rather than definitive GPF locations.

# 6.0 Construction phase impact assessment

## 6.1 Gas well construction

### 6.1.1 Proposed activity

Gas well construction involves the drilling and furnishing of production wells. A drill rig typically operates 24 hours a day on a 12 hour back-to-back shift basis. It is therefore common for any of the noise generation activities associated with drilling and furnishing of production wells to occur at any time of the day or night.

Drill rigs represent a major noise source that is present for a limited duration in relation to any specific dwelling in a quiet rural environment particularly at night-time.

The duration of drilling and furnishing a single production well varies with the depth of the coal seam. However, a period of 5 to 12 days is typical.

There are many variations to the techniques and sequencing of drilling and well-casing operations that are employed to construct gas wells, depending on the geological characteristics of the overlying strata and the depth and characteristics of the coal seam(s) targeted for gas extraction.

Australia Pacific LNG has advised that the 'cavitations' method of well completion, which can result in very high short-term (20-30 second) noise levels, may be utilised for a very small proportion of proposed wells in the gas fields.

Detailed noise sampling has previously been conducted for three drilling rigs operating in the Spring Gully area.

The acoustically significant operating modes of drill rigs are detailed in Table 11. Example drill rigs are illustrated in Figure 3 and Figure 4.

**Table 11: Significant noise sources – gas well construction**

| Gas well construction stage | Significant noise sources |
|---|---|
| **Normal well construction activities** | |
| Well site preparation<br>(duration 3-4 days) | Bulldozer, excavator and grader for forming the well lease work pad and access road preparation<br>Wood chipper, if required, to mulch vegetation |
| Drill rig setup<br>(duration 24 hours) | Movement of approximately 10 to 20 semi-trailer loads of mechanical plant and trailer-mounted buildings to site during daylight hours<br>Front-end loader forklift unloading of semi-trailer plant and equipment<br>Diesel-driven electricity generator<br>Metal-to-metal impacts associated with erection of drill-rig mast and set-up of compressed air, water treatment, mud-pumps and power systems. |

| Gas well construction stage | Significant noise sources |
|---|---|
| Well drilling<br>(duration 5-17 days) | Diesel-driven electricity generator<br>Drill-rig engine and drill-string hydraulic drive and elevation motors<br>Mud-pump and air-compressor diesel engines<br>Periodic operation of diesel-driven air-compressors, and 'hissing' compressed-air noise during venturi-induced well-unloading<br>Metal-to-metal impacts associated with connection/disconnection of drill-string segments and automated handling of drill-string segments |
| Cementing noise<br>(duration 30- 60 minutes) | Diesel-driven electricity generator<br>Multiple diesel-driven high-pressure pumps used to inject cement slurry into cavity surrounding the well casing. |
| Drill rig pull-down<br>(duration 1 day) | As for drill rig setup |
| **Other potential well treatments** | |
| Setup of well completion rig (24 hours) | As above |
| Well completion (fraccing) (duration 3 to 5 days) | Diesel-driven electricity generator<br>Multiple diesel-driven high-pressure pumps used to inject a porous slurry into the coal seam around the well foot |
| Well completion (cavitation) (duration 20 - 30 seconds for a number of cycles) | Diesel-driven electricity generator<br>Multiple diesel-driven high-pressure compressors used to pressurize the coal seam via the gas well<br>Sudden turbulent release of primarily compressed air from the coal seam via the gas well and flare line |
| Drill rig pull-down<br>(duration 1 day) | As for drill rig setup |

Detailed one-third octave noise logging at one-second intervals has previously been conducted for Origin Energy adjacent to well construction sites to characterise the various construction operations. Logging records are presented in Appendix C. The records simultaneously illustrate both the time history of standard statistical level parameters (top of page graph), and the time history of the frequency spectra of the noise (lower page graph).

The sound power spectra that have been determined for specific well-construction operations and items of plant based on noise logging records and detailed diagnostic measurements are summarised in Appendix D.

### 6.1.2 Impact assessment

***Noise criteria***

Well construction normally occurs on a 24 hour-a-day basis. The night-time assessment is therefore most relevant and most critical.

The recommended criteria are the EPP Noise 'acoustic quality objectives'. For the critical night-time period the derived unadjusted outdoor criteria for evening and night-time construction activities determined in Section 4.2.2 are 35dBA $L_{Aeq,1hr}$ and 47dBA $L_{Amax}$.

***Rig setup/pull-down***

Rig setup and pull-down operations are characterised by the movement of approximately 10 to 20 semi-trailer loads of mechanical plant and site buildings. These shifts are conducted during daylight hours. Detailed noise logging records have been obtained from a noise logger positioned in the corner of a drilling lease during the set-up cycle of a drilling rig. These indicate that the general level of noise from rig setup and pull-down was characterised by average levels of 60dBA $L_{Aeq,1hr}$ and typical maximum levels of 70dBA $L_{A1,1hr}$ at 88m from the well centre. A sample measured noise level/spectrum history for this operation is presented in Appendix C, Figure 24.

Noise levels are likely to comply with night-time criteria at distances greater than 1.5km from the well site.

***Air-drilling[20] and well-unloading***

Drilling operations result in steady noise emissions consisting of diesel and hydraulic drives and air-compressors.

Air-drilling is the noisier activity as drilling cycles are interspersed with the process of well-unloading, which is achieved using a high pressure air venturi at the end of the flare-line to induce flow up the well.

Air-drilling noise levels are typically 66dBA $L_{Aeq,1hr}$ at 88m from the well centre (refer to noise logging records in Appendix C, Figure 25), and 87dBA $L_{Amax}$ at 80m from the end of the flare-line during well-unloading (Figure 25).

The schematic in Figure 30 in Appendix E illustrates the relative significance of noise sources during the process of intermittent well-unloading, with the effectiveness of the flare-line noise barrier illustrated by noise contours in the far-field in Figure 31. The noisier well-unloading operation effectively determines the distance at which air-drilling operations can comply with the relevant acceptance criteria (35dBA $L_{Aeq,1hr}$).

From the modelling results presented in Figure 31, it is concluded that noise levels are likely to comply with night-time criteria at distances greater than 2km from the well site when the receptor is in the noise-shielded zone relative to the flare-line barrier, and at distances greater than 3.5km where there is no noise shielding.

Noise contours associated with air-drilling are illustrated in Appendix E, Figure 32. Compliance with the night-time criteria is achieved at distances greater than 2km.

***Mud-drilling[21]***

Mud-drilling operations result in steady noise emissions consisting of diesel and hydraulic drives. The level of noise generation is significantly lower than that for air-drilling, primarily because the well-unloading operation is not required.

Mud-drilling noise levels are typically 67dBA $L_{Aeq,1hr}$ and 70dBA $L_{Amax}$ at 50m from the well centre (refer to noise logging records in Appendix C, Figure 26).

[20] Air drilling utilises a flow of compressed air fed to the drill bit to cool the drill bit and transport drill spoil to the surface
[21] mud drilling utilises a flow of drilling mud to the drill bit to cool the drill bit and transport drill spoil to the surface

Noise levels are likely to comply with night-time criteria at distances greater than 1.8km from the well site.

***Cementing noise***

Cementing noise is generated by a trailer that is densely packed with diesel powered pumps that are used to inject cement slurry into the cavity surrounding the well casing at high pressure. This process occurs for a period of about 30 minutes.

Noise levels for this operation were typically 70dBA $L_{Amax}$ at 50m from the well centre. Example noise logging data from a cementing operation is illustrated in Appendix C, Figure 28.

Noise levels are likely to comply with night-time criteria at distances greater than 1.8km from the well site.

***'Fraccing' well completion alternative***

Noise associated with fraccing well completion has not been sampled, but is understood to be comparable to noise levels associated with cementing. Noise is generated by diesel-driven high-pressure pumps used to inject porous slurry into the coal seam.

***Cavitation well completion alternative***

Cavitation noise results from the sudden release of compressed air form the coal seam via the well and flare line. This process results in a turbulent horizontally-directed rush of air that generates intense broad-band noise for a period of approximately 30 seconds.

The cavitation process typically commences with two to three hours of pumping of compressed air into the coal seam, followed by the cavitation release via the flare line. This cycle may then be repeated several times over a nominal 24 hour period, with increased duration of compressed air pumping between successive releases (up to six hours). This occurs until analysis of the expelled gas composition, at the end of the cavitation release, indicates the well is ready for CSG production.

The noise level generated by cavitation is very high, at a level of approximately 115dBA at 50m. Example noise logging data from a well cavitation is illustrated in Appendix C, Figure 29. Additional microphone locations were utilised to sample the cavitation noise upstream and downstream of the end of the flare line to determine the horizontal directivity of this noise source.

Due to the short duration of the cavitation noise event, the relevant night-time assessment criterion is 47dBA $L_{Amax}$ relating to prevention of sleep disturbance. The recommended daytime and evening criterion for a cavitation event is 65dBA $L_{Amax}$, based[22] on the EPP Noise daytime and evening acoustic quality objective of 65dBA $L_{A1,adj,1hour}$.

The noise model contours in Appendix E, Figure 33 illustrate the worst-case potential for noise disturbance from a cavitation with the flare-line directed towards a dwelling. A short duration level of 80dBA $L_{Amax}$ is predicted at a distance of approximately 2km from the end of the flare line. A significantly reduced level of

[22] One percent of a one hour period is 36 seconds, which is comparable to the duration of a cavitation event. As the cavitation event is neither tonal nor impulsive, the $L_{Amax}$ parameter can be substituted as a slightly conservative approximation to the $L_{A1,adj,1hour}$ parameter for assessment purposes.

60dBA $L_{Amax}$ at 2km is predicted if a 4.6m high flare-line noise barrier is utilised, with the flare-line directed away from the receptor, as illustrated in Figure 34 and Figure 35.

It is concluded that cavitation noise mitigation could enable cavitation noise to comply with the recommended daytime and evening criterion of 65dBA $L_{Amax}$ (applicable between 7am and 10pm) at distances greater than 2km from the well. At night (10pm to 7am) compliance with the recommended night-time sleep disturbance criterion of 47dBA $L_{Amax}$ may be achieved at distances greater than 10km of a gas well.

Due to the short duration of cavitation events (approximately 30 seconds), the limited use of this well completion process and the limited number of these events at a given well (estimated at no more than 4-6 events per day), it is unlikely that cavitation events from two drill rigs working in significant proximity to a dwelling would occur simultaneously. In the unlikely event of simultaneous cavitations, the possible increase in cavitation noise level at a receptor would not be more than 3dB above the level from one cavitation event. Qualitatively this would not noticeably change the subjective significance of the event.

***Summary of well construction***

Well construction activities would comply with the recommended night-time noise goals at separations from sensitive receptors in the range of 1.5km to 3.5km, depending on the process. The exception is noise associated with the cavitation well-completion option, for which a separation of the scale of 10km would in theory be necessary to minimise the potential for sleep disturbance between the hours of 10pm and 7am.

Reduced separation distances may be achievable based on site specific noise analyses that account for noise control possibilities associated with:

- avoidance of certain louder processes during the evening or night
- favourable topography
- use of temporary barriers (that is, barrier structures, stacked shipping containers, stacked hay bales etc.)
- individual agreements or alternative arrangements with potentially affected residents.

***Cumulative impacts of multiple well constructions***

Conceptually, noise impacts from the construction of multiple wells may be cumulative in intensity and/or cumulative in duration, depending on the well-construction sequence in a gas-field.

If barriers were utilised at the flare-line end to reduce well-unloading noise to the nearest residences (relevant to air-drilled wells), the area of potential significant night-time impact from well construction activities may be reduced to within a nominal 2km radius of any well site. In some proposed gas-fields the unmitigated draft well patterns at 750m well spacing indicates there may be 10 to 20 well-sites within 2km of a dwelling. In this instance there would be potential for cumulative increase in intensity of noise impact from two or more rigs working within 2km of a dwelling.

The potential for cumulative intensity of impact versus cumulative duration of impact would depend on the alternative sequencing strategies that could be utilised for construction of multiple gas-wells. The chosen strategy may depend on the views and agreements reached with potentially affected residents.

If the drilling programme is sequenced so that a dwelling is impacted by noise from no more than one rig at a time, cumulative intensity of impact from simultaneous well-construction operations may be avoided. The maximum level of drilling noise received is minimised but the duration of construction noise amounts to the time to sequentially drill relevant holes. The cumulative duration of significant construction noise for this approach may be of the order of six months to two years, depending on the number of nearby drill sites within a nominal two kilometre radius of the receptor dwelling.

Alternatively the cumulative duration of noise impact at a dwelling could be minimised by conducting simultaneous drilling at well-sites close to a dwelling. Depending on the number of wells within 2km of a dwelling, and the number of rigs available to work simultaneously, the period of significant construction noise at the dwelling could conceivably be reduced to between two months and a year, depending on the number of drill sites within a nominal two kilometre radius of the receptor dwelling.

### 6.1.3 Noise management

***Site evaluation and community liaison***

It will be necessary to generate an environmental management plan specific to well-construction noise for the project area. In the plan it will be necessary to address the project schedule, the activities and the sources of noise and how they will be mitigated. The noise management plan should be linked to a stakeholder engagement plan the will address the process of stakeholder engagement, including, communities and landowners. The first stage of noise management could be to identify dwellings within a 4km radius of the well site and hold discussions with property owners about their views on noise associated with well-construction. For residents that have not experienced well-drilling noise, it is recommended that a field inspection be arranged to view both well-construction in progress and a complete and operational hydraulic-driven well if possible.

***Well-drilling noise mitigation plan***

A well drilling sequence and noise mitigation plan should be developed for each gas field. This plan should address the noise mitigation measures and any agreements that are made. The well drilling sequence may involve minimising either the intensity or duration of cumulative noise impacts at any given dwelling. The noise mitigation plan will likely be specific to individual well-construction rigs, as the noise emissions of individual rigs will vary as newer quieter rigs are procured over time.

The recommended outdoor noise criteria for night-time construction activities are 35dBA $L_{Aeq,1hr}$ and 47dBA $L_{Amax}$ unless alternative mitigation arrangements are agreed with potentially affected residents.

***Well-construction site noise controls***

It is recommended that the following noise controls are incorporated into the normal layout of all drill-rig sites:

- Modular reflective screens are recommended to reflect noise emissions from compressor units away from the nearest dwellings. These screens could be constructed of double-stacked long shipping containers (4.6m overall height), modular 2.4m x 4.8m x 25mm plywood noise barrier panels built to a height of 4.8m between universal columns, or hay bales.

- Modular reflective screens are recommended to reflect noise emissions from the flare pit away from the nearest residential areas. A total linear length of reflective screen of 10m would be suitable, located 5m upstream of the flare-line end. These screens could be constructed of double-stacked long shipping containers (4.6m overall height), or modular 2.4m x 4.8m x 25mm plywood noise barrier panels built to a height of 4.8m between universal columns.
- The current practice of directing the flare-line away from the nearest residence should be maintained with the aid of a map that identifies the dwelling locations.

## 6.2 Gas and water pipeline construction

### 6.2.1 Proposed activity

The gathering system (pipeline) construction involves vegetation clearance for the pipeline right-of-way, trenching, welding together of pipeline sections in the field, lowering piping into the trench, back-filling and finally vegetation/ground cover restoration.

From the perspective of any particular noise sensitive location in the vicinity of a gas or water pipeline, the complete cycle of activities is typically completed within a week during day-light working hours (excluding any delays between operations).

### 6.2.2 Impact assessment

The noise level, character and duration of pipeline trenching (with a trencher or excavator) and other pipeline operations would be comparable to that of road-paving operations. Each process would progress past the observer location within the space of a working day. The noise impact of the whole process could be compared with that of road-making experienced at a distance of at least 100m. This noise would be noticeable but acceptable during the standard daytime hours, in accordance with the default noise standards under the EP Act.

### 6.2.3 Noise management

Out-of-hours[23] trench excavation (trencher or excavator) and other pipeline construction operations within 2km of a residence should be conducted subject to approval of a noise management plan addressing the EPP Noise acoustic quality objectives.

### 6.2.4 Vibration impacts

***Earthmoving – mechanical excavation***

Levels of ground vibration associated with a range of mechanical construction vibration sources are illustrated in Figure 23.

[23] Sundays, evenings and nights as per EP Act, section 440R.

A preliminary or 'rule-of-thumb' threshold criterion for evaluating the significance of ground vibration on 'sound' structures is a peak particle velocity of 5mm/s. Referring to Figure 23, normal construction processes are unlikely to generate vibration levels over 1mm/s at receiver distances greater than 100m.

It is concluded that adoption of a minimum separation distance of 100m between the pipeline alignment and sensitive dwellings or commercial premises would ensure no vibration impact to buildings associated with any possible mechanical earth moving or excavation technique (trencher, excavator, rock-sawing, rock-hammering, directional drilling).

***Blasting excavation***

There are no specific locations where it is known that blasting will be required in the vicinity of residences or commercial properties.

However, if blasting is required, the blast will be designed to comply with the statutory criteria set down in Section 4.4 and with regard to any particular vibration requirements or sensitivities of the nearby receptor location(s).

The level of vibration associated with blasting is controlled by the number, mass and depth of explosive charges used in a blast. Formulae for estimating the vibration level resulting from a given charge mass at a given distance can be found in Appendix J of AS 2187.2-2006.

Blast vibration can be felt at levels much lower than levels that damage property. Perception of vibrations and possible rattling of windows and contents often leads to heightened awareness and discovery of cracks that are usually pre-existing. It is critical therefore that where concern about cracking may arise as a result of significant 'noticeable' vibration, consultation with residents be undertaken ahead of construction commencing. A pre-construction inspection of the building condition by both the owner and a construction representative should be conducted if there is a perceived threat to the value of the property, with post-construction follow-up inspection if necessary.

Vibration monitoring should be considered if predicted vibration levels are more than 20% of the statutory vibration limit values. Lower vibration goals should be considered in the case of heritage-listed structures, or where there is elevated sensitivity of persons (e.g. infirmity) or building contents to vibration.

## 6.3 Gas processing facility construction

GPF construction involves conventional industrial building techniques for site preparation, foundation pouring and erection of metal framed buildings. Complaints about GPF construction noise are unlikely during normal daytime working hours. This is due to the relatively large separation distances between GPFs and sensitive locations that necessarily forms part of the operational noise mitigation strategy.

## 6.4 Construction camps

Accommodation camps are a minor source of noise associated with construction. Normal noise sources include domestic reverse-cycle split-type air-conditioning units, kitchen exhaust fan and power generation plant. At a distance of greater than 500m, the only noticeable noise associated with the camp is passing vehicular traffic associated with the camp in the morning and evening. Camps are not utilised for loud outdoor recreation, such as amplified music, as the proper rest of employees living in these camps is paramount.

### 6.5 Construction traffic and transport

The potential for significant traffic and transportation noise impacts lies in the use of quiet country roads close to residences during the night or early morning, when traffic may otherwise be very low or completely absent. This could result in sleep disturbance or unwanted noise intrusion to individuals and would be subject to individual circumstances and sensitivities.

There may be potential for significant transportation noise impacts at residences along typically quiet country roads during the night or early morning. It is recommended that deliveries to construction sites occur in compliance with an approved traffic management plan to minimise noise disturbance during the night or early morning.

# 7.0 Operational phase impact assessment

## 7.1 Well pump drives

### 7.1.1 Proposed plant

Gas wells are not normally connected to the electricity grid so must be supplied with a stand-alone drive system.

The motive system proposed to drive the well pumps is a CSG powered reciprocating engine that hydraulically drives[24] the well pump. An example of a well-head driven by a 50kW Oil-lift hydra-pack is shown in Figure 5.

The actual pump is not a significant noise source as it is located hundreds of metres below ground at the bottom of the gas well, driven by a shaft connected to the above-ground drive unit.

The minimum spacing between gas wells is typically 750m. Towards the end of the production life of a gas-field, it is likely that most or all well pumps within a gas field would be running simultaneously.

### 7.1.2 Noise characteristics

Noise level sampling was conducted for the range of hydraulic and electric well-pump drives currently utilised in Origin Energy's gas fields to determine the comparative sound power output and tonal characteristics of current alternative drive technologies.

The comparative sound power spectra for the alternative well-pump drives are presented in Figure 6, and numerically in Appendix D. All reciprocating engine drives produce a low-frequency exhaust hum that is evident as a peak in the sound power spectrum in the range of 50Hz to 100Hz. This hum has sometimes been the focus of noise complaints.

The comparative sound pressure level versus distance characteristic for the alternative drives is presented in Figure 7. This data indicates that with the exception of the 'old oil-lift' drive, which is much louder than all other drives, the overall sound pressures from the other three drives (Kudu, new Oil-lift and twin-microturbine) are comparable.

### 7.1.3 Impact assessment

The target night-time PNL for total plant noise received at any location is 28dBA $L_{Aeq,adj}$.

The noise impact of a modern 50 kW hydraulic well-drive can be determined from Figure 7. This data indicates that unmitigated wells could be located with at a minimum separation of 500m from a dwelling if contributions from other plant items are negligible. This would achieve an unadjusted contribution of 25dBA, with possible mild tonality adjustments of 2-3dBA bringing the assessed level up to 28dBA $L_{Aeq,adj}$ at 500m.

[24] A hydraulic pump coupled to the reciprocating gas engine drives, via hydraulic lines, a hydraulic motor coupled to the well pump.

The total noise contribution of multiple driven well-heads may increase the separation needed where a dwelling is located within a gas field. The highest number of driven well-heads occurs towards the end of the gas field life when it may be assumed, for noise modelling purposes, that all well-heads would be driven simultaneously. Modelled noise contours for this situation are presented in Appendix E, Figure 36. The unmitigated well distribution is a minimum well separation of 750m.

It is concluded from the modelling results that a minimum separation of 600m would be needed between wells and a dwelling within a gas field, and 500m for a dwelling adjoining the edge of a gas-field, to achieve a total plant level from multiple wells not exceeding 28dBA $L_{Aeq,adj}$.

This result applies where other sources of noise are not significant (for example, GPF noise) and for flat ground with negligible forest. The situation would be more favourable with significant forest, and could be helped or hindered by topography depending on whether hills obscured or enhanced line-of-sight between a dwelling and well-heads.

It may be necessary to increase the minimum separation from wells to maintain a total noise contribution from mechanical sources not exceeding 28dBA $L_{Aeq,adj.}$ where noise from well-heads interacts with noise from a GPF. This would depend entirely on the relative significance of GPF and well noise at any particular location.

## 7.2 Gas processing facilities

### 7.2.1 Proposed plant

GPFs are the largest long-term noise source associated with CSG production. The primary function of a GPF is to collect gas from a number of wells in a gas field (nominally within a 9km radius), process the gas to transmission specification and push the gas at high pressure along a trunk gas pipeline towards either a gas-fired power plant or LNG plant.

GPF capacities in the range of 75TJpd to 225TJpd would be utilised to match the gas production potential of the various gas fields in the study area. An example of an existing 60TJpd plant is illustrated in Figure 8.

There are a range of technologies that can be utilised within the GPF to provide the motive power (reciprocating gas engines or electric drives), gas compression (reciprocating or screw compressors) and cooling (mechanical or electric driven fans). The optimal selection of technologies depends on the availability of electrical power, the characteristics of the gas field productivity and site-specific noise constraints.

The basic GPF description consists of between 11 and 30 gas compression units, consisting of a combination of the following two compression unit types:

- CSG powered reciprocating gas engine, directly connected to reciprocating-type compressor. The proposed drive engine is a Caterpillar G3616 16 cylinder, 339 litre displacement gas engine as shown in Figure 9. The compressor is a six-cylinder horizontally opposed multi-stage unit illustrated in Figure 10.

- CSG powered reciprocating gas engine, directly connected to a screw-type compressor. The proposed drive engine is a Caterpillar G3620B 20 cylinder, 86 litre displacement gas engine. An example Gardner Denver screw compressor is shown in Figure 11.

Each gas compressor requires cooling. For compressors driven by reciprocating gas engines, cooling is normally provided by a series of mechanical fans on a horizontal shaft driven by the gas engine, as illustrated in Figure 12. The cool air is drawn in through the sides and end of the unit and expelled upwards.

When the gas production from a gas field temporarily exceeds the capacity of the operating gas compressors, the remainder is burnt in a flare. This typically occurs if a gas compression unit shuts down due to a process fault. The gas throughput of that compression unit is flared until the gas engine is restarted, or the flow from the gas wells re-balanced to the available GPF capacity. An example flare is illustrated in Figure 13.

Flare noise is a minor source of noise relative to the total noise of the GPF and is only discernible in the context of other GPF noise at relatively short distances from the flare.

### 7.2.2 Noise characteristics

The noise impact of the proposed larger capacity 75TJpd, 150TJpd and 225TJpd GPFs has been scaled from measurements of noise conducted at the existing operational Spring Gully 60TJpd GPF, which runs reciprocating compressors, and the Rockwood 7.5TJpd booster GPF, which runs screw compressors.

The Spring Gully GPF consists of five CSG compression trains comprising Caterpillar G3616 reciprocating gas-engine driver, 3-stage reciprocating compression train, and Harsco Model 132 F4 shaft driven fan cooler. Noise controls include high performance silencers on reciprocating engine exhausts, a solid back wall to provide directional noise attenuation, and an insulated roof joining the solid back wall. The source sound power spectra for the Spring Gully GPF is summarised in Appendix D. The modelled near-field noise contours around the Spring Gully GPF are illustrated in Appendix E, Figure 37.

The Rockwood GPF consists of two CSG compression trains comprising Waukesha F18GL reciprocating gas-engine driver, Gardner Denver screw compressor, and Model Moore-CL10K/96BEH shaft driven fan cooler. The Rockwood GPF is open with high performance silencers on reciprocating engine exhausts. The source sound power spectra for this plant is summarised in Appendix D.

The sound output of the larger GPFs has been estimated based on the noise output of Spring Gully and Rockwood GPFs as described in Table 12.

**Table 12: Basis for generic GPF noise modelling**

| Generic GPF capacity | Compressor composition | Basis for total modelled GPF sound power |
|---|---|---|
| 75TJpd | 4 reciprocating<br>7 screw | 0.8 x Spring Gully GPF + 3.5 x Rockwood GPF |
| 150TJpd | 7 reciprocating<br>13 screw | 1.4 x Spring Gully GPF + 6.5 x Rockwood GPF |

| Generic GPF capacity | Compressor composition | Basis for total modelled GPF sound power |
|---|---|---|
| 225TJpd | 10 reciprocating<br>20 screw | 2 x Spring Gully GPF + 10 x Rockwood GPF |

The calculated sound power spectra for 75TJpd and 150TJpd GPFs are presented together with the Spring Gully and Rockwood base data in Figure 14 (the 225TJpd data is 1dB higher than the 150TJpd data but has been omitted for clarity). The flare noise data relates to the flaring of one-fifth of the Spring Gully throughput, or 12TJpd. Numerical sound power data, including the 225TJpd GPF capacity, is presented numerically in Appendix D.

The comparative sound pressure level versus distance characteristic for the base GPFs and derived 75TJpd and 150TJpd GPFs is presented in Figure 15.

The audible characteristic of the Spring Gully GPF at 1500m is a low-frequency broad-band ‘rumble’ sound associated with mechanical fan turbulence. The Rockwood GPF produces an additional ‘whine’ noise within the 10kHz band, which is distinctive near to the plant (up to 500m) but indiscernible at greater distances, due to the naturally higher sound attenuation with distance of higher frequencies. No penalties would be applicable for tonality or impulsivity for either plant at distances greater than 1500m. It is concluded therefore that for larger GPFs, comprising a combination of engine-driven reciprocating and screw compressors, the sound character at distances greater than 1500m would also be broad-band in character. A 0dB adjustment for tonal or impulsive characteristics would therefore be applicable.

The calculated one-third octave spectrum at an example receiver distance of 3km for a range of existing and projected plant capacities is illustrated in Figure 16. This graph illustrates the low significance of flare noise at distance compared to other GPF noise.

### 7.2.3 Impact assessment

The impact of GPF noise has been assessed for this study by reporting noise emissions associated with the standard Spring Gully and Rockwood GPF technology as a basis for determining the range within which this standard technology would result in acceptable noise impacts for the simplified flat-terrain scenario. In the case of the Spring Gully data, the effect of the reflecting back wall was excluded for the analysis of 'standard' plant emissions. The benefits of quieter technologies for compressor drivers and fans, and noise enclosures for compressor drivers are also presented.

The target night-time planning noise level (PNL) for total plant noise received at any location is 28dBA $L_{Aeq,adj}$.

***Standard GPF plant with no additional noise mitigation***

The approximate range of acceptable noise impacts associated with a 75TJpd or 225TJpd GPF can be determined from the level versus distance predictions in Figure 15. This data indicates that a 225TJpd plant (1dB higher than 150TJpd) could be located at a minimum distance of 5.6km from dwellings to meet the 28dBA $L_{Aeq,adj}$ objective. This distance could be reduced to 5km for a 150TJpd plant and 4.1km for a 75TJpd plant.

***Effect of optimal engine/compressor enclosure with standard fans***

The best possible effect of engine/compressor enclosures in combination with standard design fans has been examined by modelling the effect of 100% effective enclosure of the engine/compressors (by completely removing these noise sources), reducing the significant noise sources to open-air fan-coolers (Spring Gully type) and attenuated engine exhausts. This was found to reduce the overall GPF sound power by 6dBA at the source. This source improvement is primarily achieved by reductions in higher frequency noise components associated with the engines and compressors, with the lower frequency emissions predominantly associated with fan-coolers reduced to a lesser degree. The reduction in far-field noise levels is therefore less than the source level reduction, since lower frequency noise attenuates less with distance. The significance of fan-cooler noise at an example distance of 3km is illustrated in Figure 16.

The effect of this control on the nominal distance for compliance is summarised in Table 13. It should be noted that the results do not account for directional effects achievable by barriers, or the benefits of optimal GPF siting with respect to site-specific topographic shielding (that is, hills).

**Table 13: Effect of optimal engine/compressor enclosure on recommended minimum separation from sensitive receptors**

| Generic GPF capacity | Standard open GPF design | Total enclosure of engine/compressor noise - standard fan-cooler noise remaining |
|---|---|---|
| 60TJpd | 3.6km | 2.9km |
| 75TJpd | 4.1km | 3.1km |
| 150TJpd | 5.0km | 3.9km |
| 225TJpd | 5.6km | 4.4km |

It is concluded that a completely effective enclosure of the engine/compressor units improves the situation significantly, but the GPF noise constraints would remain of the same order of magnitude as the un-enclosed situation if standard fans are retained.

It is noteworthy that the remaining contribution of engine exhausts is insignificant compared with the noise of the fan coolers. Thus, if the reciprocating engines were replaced with electric drives to remove the exhausts as a noise source, the noise emission would be unchanged because the fan noise is dominant. Electric drives would, however, enable much smaller, cost-effective enclosure of engine/compressor sets.

This analysis indicates that fan noise control is a critical design issue, through fan selection and/or design of fan inlet and discharge noise attenuators, if GPFs are to be located much closer than 3km to 4km of residences.

***Effect of optimal orientation of plant with solid back wall***

Construction of the GPF with a solid back wall, such as has been done at Spring Gully, can significantly reduce GPF noise in the direction behind the solid wall. Far from the GPF, the modelled improvement is approximately 3dBA under adverse meteorological conditions. The reduced distance from a GPF that the 28dBA target could be achieved by optimal location is summarised in Table 14.

**Table 14: Effect of orientation of GPF on recommended minimum separation from sensitive receptors**

| Generic GPF capacity | Standard open GPF design | Standard open GPF with solid back wall facing receptor (3dBA improvement) |
|---|---|---|
| 60TJpd | 3.6km | 2.9km |
| 75TJpd | 4.1km | 3.3km |
| 150TJpd | 5.0km | 4.0km |
| 225TJpd | 5.6km | 4.5km |

By comparing results in Table 13 and Table 14, it can be seen that if noise attenuation was critical with respect to one receptor only, then a solid back wall could be as effective an attenuation measure as full enclosure of engines and drivers.

***Least noise case for enclosed electric compressor drivers with low-noise fans***

The lower limit to possible GPF source noise emissions would be achieved with enclosed electrically driven compressors, and low-noise cooling fans powered by variable speed electric motors. The fan capacity would be optimally matched to the heat-load of compressors, to achieve the minimum possible number of fans per compression train. Electric drives would need to be either connected to the electricity grid or locally supplied with electricity from a gas turbine generator (GTG). As GTGs are also a significant noise source, the siting of the GTG may be subject to similar noise constraints as those that apply to a GPF[25]. The potential impact of GTG noise has not been investigated for this project.

The comparative improvement of this limiting low-noise case, relative to the standard plant scenario, is illustrated for the Spring Gully GPF example as the darker green line in Figure 17. It can be concluded that the minimum separation of GPF from a noise sensitive location can be substantially reduced by selecting low-noise fans and enclosing the compressor drivers. A continuum of intermediate noise performance curves are possible between the low-noise limiting case (darker green line on Figure 17) and the standard plant design (red line) depending on the particular acoustic constraints that are present at a proposed GPF site. This continuum is achieved by varying the type of compressor driver, the performance of the sound enclosure and the noise performance of the cooler fans.

***Proposed low-noise case with enclosed reciprocating compressor drivers and low-noise fans***

Where site acoustic constraints require a high degree of noise control it is proposed to utilise a combination of low-noise cooler fans and acoustic enclosure of the reciprocating engine and compression trains.

The proposed low-noise GPF design would utilise low-noise fans such as the Howden 13SX4 model (refer Appendix D Table 26 for data) with fully-enclosed reciprocating compressor-drivers. The transmission loss performance of the enclosure would be comparable or better than the Enerflex EFX-100 panel data included in Appendix D Table 28, with penetrations, ventilation openings and access

[25] The consideration of GTG noise was beyond the scope of this study at the time of reporting.

doors acoustically treated to ensure the acoustical integrity of the enclosure is not degraded.

The comparative improvement of this proposed low-noise case, relative to the standard plant scenario is illustrated for the Spring Gully GPF example by the lighter green line in Figure 17.

The effect of GPF capacity on noise dispersion for the proposed low-noise GPF design is illustrated in Figure 18. The recommended minimum separation for this low-noise case compared to the standard technology case is summarised in Table 13.

**Table 15: Effect of limiting case low-noise technology on recommended minimum separation from sensitive receptors**

| Generic GPF capacity | Standard open GPF design | Enclosed reciprocating compressor drivers and low noise fans |
|---|---|---|
| 60TJpd | 3.6km | 1.1km |
| 75TJpd | 4.1km | 1.3km |
| 150TJpd | 5.0km | 1.6km |
| 225TJpd | 5.6km | 1.9km |

It is concluded that for the proposed low-noise case, the minimum separation distance adjacent to a 150TJpd GPF could be reduced to around 1.6km, which is approximately one-third of the nominal minimum separation recommended for a standard technology GPF.

***Effect of combined GPF and gas well noise***

Where the nearest dwelling to a GPF is located within a gas field, the total noise contribution of the GPF and multiple driven well-heads should be considered during detailed design. The appropriate design sequence is to first design an acceptable solution with respect to the GPF noise (the larger noise source). Additional noise control should then be applied as required to well-drives nearest the dwelling. The most likely form of noise control at a well-head is a portable free-standing noise screen/barrier that is re-deployable, does not impede well maintenance and does not introduce issues of gas explosion risk that may be associated with well-head enclosure concepts.

### 7.2.4 Low-frequency noise

The C-weighted outdoor noise level has been calculated to be less than 54dBC when the received level is no more than 28dBA $L_{Aeq,adj.}$ for all plant capacities considered. There is therefore no plant proposed that would generate enough low frequency noise to be significant in respect of the recommended guideline of 60dBC outdoors.

### 7.2.5 Cumulative impacts of new and existing GPFs

Reliable assessment of cumulative impacts of multiple GPFs requires defined GPF plant locations and receptor locations.

However, from the nominal flat-terrain dispersion data presented in Figure 15 it is concluded that where there are two or more standard technology GPFs within 6km to 7km of a dwelling, and topography provides insufficient noise attenuation, there may be potential for a cumulative noise impact exceeding the 28dBA $L_{Aeq,adj}$ target.

These instances would be considered on a case-by-case basis and suitable noise mitigation measures would be considered for each GPF to achieve compliance with the criteria.

The minimum recommended separation from sensitive receptors for individual GPFs with proposed low-noise technologies, can be made much less than the separation between GPFs, thereby avoiding significant cumulative noise impacts.

## 7.3 Water treatment facilities

### 7.3.1 Proposed plant

Proposed water treatment facilities (WTFs) would be similar to the existing Spring Gully WTF. An example of the WTF reverse-osmosis plant is illustrated in Figure 19 and Figure 20.

If WTFs are powered by CSG rather than mains electricity, as is proposed, the most significant noise source becomes the reciprocating gas engines for WTF electricity generation. The WTF electricity generation is housed in an acoustic enclosure in current facilities. An example of such a plant, viewed inside and outside the sound-proofed enclosure, is illustrated in Figure 21.

A third noise source associated with a WTF is the water transfer pumps that shift water from the untreated water storage to the filtration and reverse-osmosis plant. This plant is illustrated in Figure 22.

### 7.3.2 Noise characteristics

Compared to a GPF, the reverse-osmosis pumping and filtering processes of a WTF plant are relatively quiet. This noise consists predominantly of broad-spectrum high-frequency noise that is effectively controlled by a standard metal shed enclosure. The audibility of this plant is minimal at distances greater than 250m beyond the WTF building.

Sound power spectra for the water transfer pumps, generation plant and the typical sound pressure spectrum within the reverse-osmosis plant building are detailed in Appendix D.

The power generation plant typically generates a significant 'hum' associated with the exhaust noise. This hum may attract a 2-3dBA tonal penalty at a measured level of 25dBA under quiet background noise conditions.

### 7.3.3 Impact assessment

Noise contour modelling has been prepared for a generic WTF based on the noise data presented in Appendix E. The results of this noise modelling are presented in Figure 38.

New WTFs constructed with noise controls to the same standard as Spring Gully can be expected to comply with the 28dBA $L_{Aeq,adj}$ limit at distances greater than 1000m from the generation plant. A 2dBA to 3dBA tonal penalty for power generation plant hum is included in this assessment.

This assessment assumes flat topography and no particular orientation of the WTF relative to a sensitive receptor. Favourable location of the WTF building between the generation plant and a receptor, so that the building has a secondary noise barrier benefit to the receptor, may enable compliance at a reduced separation distance of 500m.

# 8.0 Summary and conclusions

This analysis of noise impacts has been presented for the simplified worst-case flat-terrain scenario. Substantially improved attenuation between noise sources and a receptor may occur where site selection is able to achieve intervening ridges/hills, and where significant forest occurs close to the source and/or receiver.

The minimum recommended separation distances to achieve noise criteria at sensitive receptors may therefore be subject to reductions where siting factors are favourable.

This proviso applies to all conclusions drawn in relation to all construction and operational noise sources.

## 8.1 Baseline Noise Levels

Baseline ambient noise levels were sampled at 25 sites representing noise sensitive locations across the proposed Australia Pacific LNG gas fields.

Background levels were consistently very low across the study area, with evening and night-time rating background noise levels (RBLs) typically at or below 15dBA. Only sites close (i.e. within 1000m) to major highway routes displayed higher night time RBLs of up to 18 dBA.

## 8.2 Construction impacts

### 8.2.1 Noise limits

Noise limits are not applicable to construction noise within the nominal regulated construction hours of 6.30am to 6.30pm on business days and Saturdays, as defined in the EP Act, providing that reasonable steps are taken to minimise noise impacts as may be judged by an authorised officer.

The recommended noise criteria for assessment of temporary out-of-hours construction noise are the numerical acoustic quality objectives listed in the EPP Noise and the sleep disturbance criteria contained within the DERM 'planning for noise control' guideline.

### 8.2.2 Gas well construction

***Individual well construction impact***

Well construction normally occurs on a 24 hour-a-day basis. The night-time assessment is therefore most relevant to noise management.

Well construction activities within 1.5km to 3.5km of a dwelling (depending on the process) would likely need additional noise mitigation to meet recommended limits for out-of-hours construction work. The exception to this is noise associated with the cavitation well-completion option, for which a separation of the scale of 10km or greater may be necessary to achieve the recommended sleep disturbance criterion between the hours of 10pm and 7am. It is recommended that cavitation be conducted during regular construction hours, where practical.

Reduced separation distances may be possible based on site specific noise analyses that account for noise control possibilities associated with:

- favourable topography
- use of temporary barriers (that is, barrier structures, stacked shipping containers, stacked hay bales etc.)
- individual agreements or alternative arrangements with potentially affected residents

***Cumulative impacts of multiple well constructions***

The night-time noise impact of well construction activities may be significant within a nominal 2km radius of any well site with current technologies and noise controls. Unmitigated well patterns based on 750m spacing indicate that there may be ten to twenty well-sites within 2km of existing dwellings.

The total duration of noise impacts from drilling, at a dwelling bordering or surrounded by a proposed field of gas wells, may range from two months to two years depending on the number of wells that are simultaneously constructed near (nominally within 2km of) a dwelling.

***Noise management***

For residents likely to be affected that have not experienced well-drilling noise, it is recommended that the process and indicative noise be described and a field inspection be arranged, where practicable.

An environmental management plan (EMP) specifically addressing noise management should be completed following the submission of the EIS and completion of front-end engineering and design. The EMP would address the proposed drilling program and noise management within each of the geographical project areas. The noise EMP should refer to a community consultation management to ensure consistent approaches to community and landholder engagement.

The noise mitigation plan will likely be specific to individual well-construction rigs, as the noise emissions of individual rigs will vary as newer quieter rigs are procured over time.

The recommended outdoor construction noise criteria for out-of-hours construction activities are generally the EPP Noise 'acoustic quality objectives' and the DERM Guideline sleep disturbance recommendations at night. In the specific instance of night-time construction, the recommended derived outdoor noise goals are 35dBA $L_{Aeq,1hr}$ and 47dBA $L_{Amax}$, unless alternative mitigation arrangements are negotiated and agreed to by potentially affected residents. A daytime noise criterion of 65dBA $L_{Amax}$ is recommended for the management of daytime and evening cavitation noise, should this well-completion option be used.

***Well construction site noise controls***

It is recommended that the following noise controls are incorporated where required into the layout of drill-rig sites near dwellings and other sensitive receptors:

- Modular reflective screens to reflect noise from compressor units away from dwellings. These screens could be constructed of double-stacked long shipping containers (4.6m overall height), modular 2.4m x 4.8m x 25mm plywood noise barrier panels built to a height of 4.8m between universal columns, or hay bales.

- Modular screens to reflect noise from flare-pit away from dwellings. A total linear length of reflective screen of 10m would be suitable, located 5m upstream of the flare-line end. These screens could be constructed of double-stacked long shipping containers (4.6m overall height), or modular 2.4m x 4.8m x 25mm plywood noise barrier panels built to a height of 4.8m between universal columns.
- The current practice of directing the flare-line away from the nearest dwelling should be maintained.

#### 8.2.3 Other construction impacts

***Pipeline and GPF construction***

Out-of-hours[26] pipeline and GPF construction within 2km of a residence should be conducted subject to approval of a noise management plan addressing the recommended construction noise limits.

Adoption of a minimum separation distance of 100m between the pipeline alignment and sensitive dwellings or commercial premises would ensure no vibration impact to buildings associated with any possible mechanical excavation technique (trencher, excavator, rock-sawing, rock-hammering, directional drilling).

If blasting is required, the blast will be designed to comply with the statutory criteria set down in Section 4.4 and with regard to any particular vibration requirements or sensitivities of the nearby receptor location(s).

Vibration monitoring should be considered if predicted vibration levels are more than 20% of the statutory vibration limit values. Lower vibration goals should be considered in the case of heritage-listed structures, or where there is elevated sensitivity of persons (e.g. infirmity) or building contents to vibration.

Any construction blasting should be conducted to maintain a minimum 100m buffer from all identified heritage structures, in addition to site-specific adoption of appropriate vibration management goals.

***Construction camps***

It is recommended that accommodation camps be located at a distance of greater than 500m from existing residences and other sensitive receptors.

***Traffic and transport***

The potential for significant transportation noise impacts relates to possible impact at residences along typically quiet country roads during the night or early morning. It is recommended that deliveries to construction sites occur in compliance with an approved traffic management plan to minimise noise disturbance during the night or early morning. In the instance of private roads terms and conditions of access are negotiated prior to access.

[26] Sundays, evenings and nights as per EP Act, section 440R.

## 8.3 Operational impacts

### 8.3.1 Noise limits

Baseline noise monitoring at 25 sites throughout the study area has demonstrated that night-time rating background levels (RBLs) are typically at or below 15dBA.

The target night-time planning noise level (PNL) advised by DERM and the applicable guideline for total plant noise received at any dwelling or other sensitive receptor is 28dBA $L_{Aeq, adj}$.

The significant difference between RBLs and the night-time PNL for new noise sources highlights the possibility that noise emissions from the CSG production plant, at levels that just comply with the DERM Guideline, may be audible at residential locations when background noise levels are close to the RBL.

The degree to which the noise is likely to be audible would depend critically on the presence or absence of distinctive sound characteristics in the noise generated by GPFs. Characteristics such as whistles, whines, hums and throbbing may increase the subjective audibility of a source of noise above that which would be indicated by the overall sound level.

### 8.3.2 Well-head drive noise

A nominal minimum separation of 600m is recommended between a dwelling and operational well-heads where this dwelling is located within a gas field. This nominal separation could be reduced to 500m for a dwelling adjoining the edge of a field of well-heads.

The recommended minimum separation distances could be reduced by implementing additional noise controls at the well-heads nearest the dwelling. The most likely form of noise control at a microturbine-driven well head is a portable free-standing noise screen/barrier that is re-deployable, does not impede maintenance of well-head plant, and does not introduce issues of gas explosion risk that may be associated with enclosure concepts.

Additional well-head noise mitigation may be necessary with respect to a dwelling if noise from other sources (for example, a GPF or WTF) is significant.

### 8.3.3 Gas processing facility noise

The potential noise impacts from GPFs at residences was assessed using modelling based on measured noise emissions from comparable technology at the existing Spring Gully and Rockwood GPFs, scaled to the proposed GPFs capacities of 75TJpd, 150 TJpd and 225TJpd.

From modelling, it is concluded that the minimum separation necessary between GPFs and dwellings ranges from 4.1km to 5.6km for existing technology GPFs in the range of 75TJpd to 225TJpd, to between 1.3km and 1.9km for proposed quiet technology GPFs of comparable capacity, that utilise a combination of low-noise cooler fans and acoustic enclosure of the reciprocating engine and compression trains.

Significant scope is therefore available to tailor GPF mechanical plant selections and noise controls to suit GPF sites affected by acoustic constraints.

***Best effect of engine/compressor enclosure for existing technology GPFs***

The best possible effect of acoustic enclosures around engines and compressors for existing technology GPFs has been explored by completely removing the engine and compressor noise from the noise model. Mechanical fan-cooler noise is then the only significant remaining noise source. With this change, a 225TJpd plant could be located at distances greater than 4.4km from dwellings, 3.9km for a 150TJpd plant and 3.1km for a 75TJpd plant.

It is concluded from this modelling result that a completely effective enclosure of the engine/compressor units improves the situation significantly, but the GPF noise constraints would remain of the same order of magnitude as the un-enclosed situation if standard design fans are retained.

This analysis indicates that fan noise control is a critical design issue, through fan selection and/or design of fan inlet and discharge noise attenuators, if GPFs are to be located within 3km to 4km of residences.

***Effect of optimal orientation of a GPF built with a solid back wall***

Construction of the GPF with a solid back wall, such as has been done at Spring Gully, can significantly reduce GPF noise in the direction behind the solid wall. Far from the GPF, the modelled improvement is approximately 3dBA under adverse meteorological conditions. With optimal orientation relative to the nearest receiver and otherwise standard GPF design, a 225TJpd plant could be located at distances greater than 4.5km from dwellings, 4.0km for a 150TJpd plant and 2.9km for a 75TJpd plant.

Noise emissions would be slightly increased by 1-2dBA in opposing directions.

It can be concluded that providing noise attenuation is critical with respect to one receptor direction only, a solid back wall combined with GPF orientation may be as effective an attenuation measure as full enclosure of engines and drivers.

***Least noise case for enclosed electric compressor drivers with low-noise fans***

Modelling indicated that a 150 TJ GPF with enclosed electrically driven compressors, and low-noise cooling fans powered by variable speed electric motors could meet recommended criterion at a distance of 1,000m. This is approximately one-fifth of the nominal sensitive receptor separation distance required for a standard technology GPF.

If power for electric drives were to be supplied locally from a gas turbine generator (GTG), noise emissions would need to be assessed under a separate approval.

***Proposed low-noise case with enclosed reciprocating compressor drivers and low-noise fans***

The proposed low-noise GPF design would utilise low-noise fans with fully-enclosed reciprocating compressor-drivers.

The minimum separation distance adjacent to a low-noise case, 150TJpd GPF could be reduced to around 1.6km, which is approximately one-third of the nominal sensitive receptor separation distance required for a standard technology GPF.

***Effect of combined GPF and gas well noise***

The total noise contribution of the GPF and multiple driven well-heads may need to be considered during detailed design for the integrated system of the GPF and gas wells where the nearest dwelling to a GPF is located within a proposed gas field. The appropriate design sequence is to first design an acceptable solution with respect to the GPF noise (the larger noise source), with noise control for well-drives addressed second.

***Low-frequency noise***

Proposed plant would not generate significant levels of low frequency noise at receptor locations when overall A-weighted noise levels are compliant with recommended noise limits.

***Cumulative impacts of new and existing GPFs***

Reliable assessment of cumulative impacts of multiple GPFs requires defined GPF plant locations and receptor locations, and would be highly dependent on the specific technologies used at a given site.

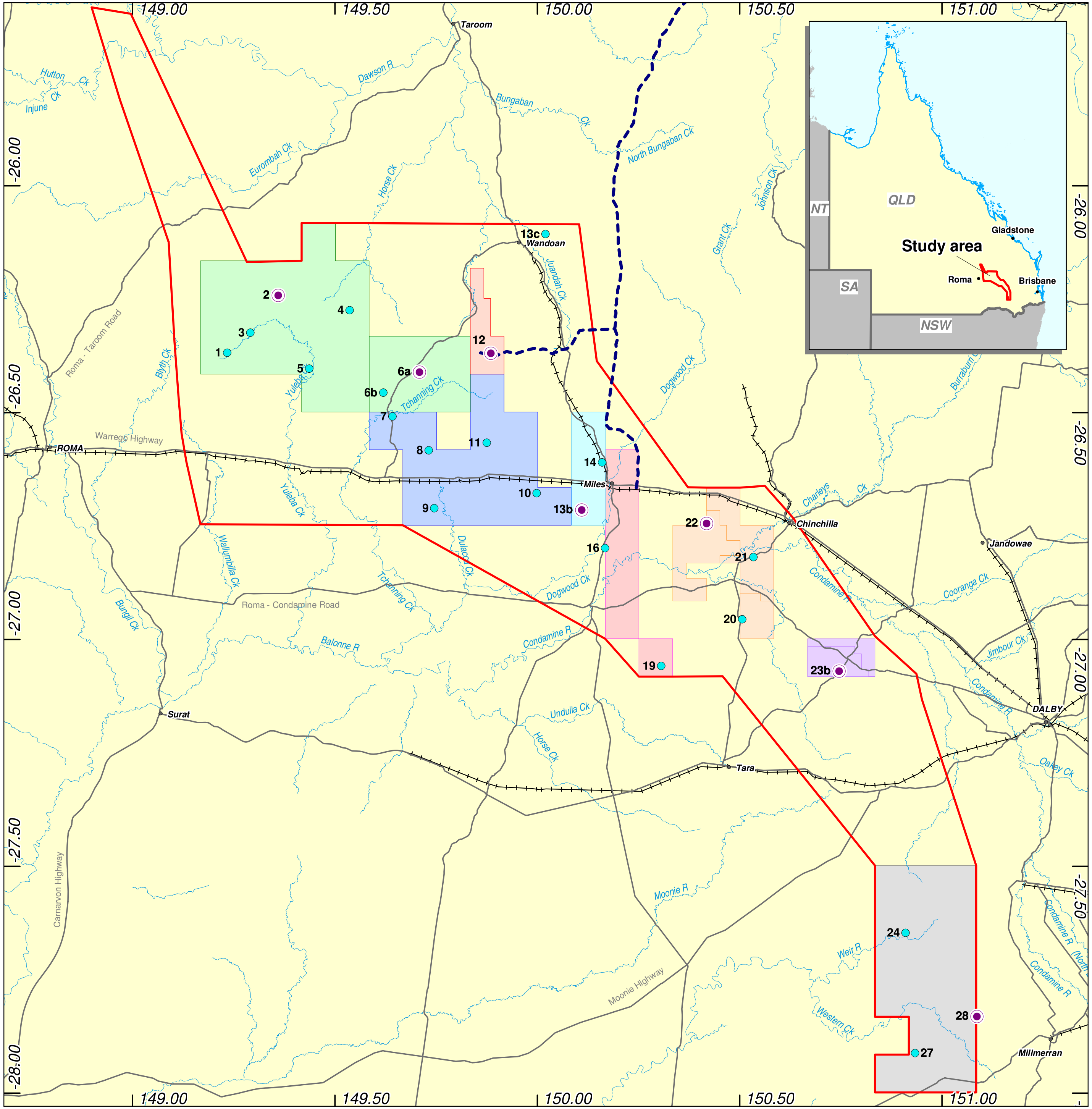
In general, it is concluded that where there are two or more standard technology GPFs within 6km to 7km of a dwelling there may be potential for a cumulative noise impact exceeding the 28dBA $L_{Aeq,adj}$ target.

The separation from sensitive receptors for individual GPFs with low-noise technologies can be made much less than the separation distance between GPFs, thereby avoiding significant cumulative noise impacts.

#### 8.3.4 Water treatment facility noise

New WTFs constructed with noise controls to the same standard as Spring Gully can be expected to comply with the 28dBA $L_{Aeq,adj}$ noise limit at distances greater than 1000m from the generation plant. This assessment allows 2-3dBA tonality adjustment for the power generation plant noise characteristics. A reduced separation distance of 500m may be possible through favourable WTF orientation.

# Figures




## LEGEND

- • Major town
- Noise monitoring location
- Noise and meteorological monitoring location
- Existing railway
- Road
- Major watercourse

***Development Area***

- Combabula / Ramyard
- Woleebee
- Carinya
- Condabri
- Talinga / Orana
- Dalwogan
- Kainama
- Gilbert Gully

- Gasfield study area
- Preferred pipeline alignment



Preferred pipeline alignment supplied by Origin Energy on 03/11/2009
Noise and meteorological monitoring locations provided by Savery and Associates Pty Ltd 27/05/2009

0 25 50km

SCALE - 1:1,000,000 (at A3)
Latitude / Longitude
Geocentric Datum of Australia 1994

N W E S

| Rev | Date | Revision Description | ORIG | CHK | ENG | APPD |
|---|---|---|---|---|---|---|
| 0 | 11/12/2009 | Issued for squad check | JC | DH | | |

WorleyParsons
resources & energy

***AUSTRALIA PACIFIC LNG PTY LIMITED***

**AUSTRALIA PACIFIC LNG PROJECT EIS**

**Noise and Meteorological Monitoring Locations**

Project No: 301001-00448 | Figure: 00448-00-EN-DAL-0401 | Rev: 0

Compiled by BRISBANE INFRASTRUCTURE GIS SECTION

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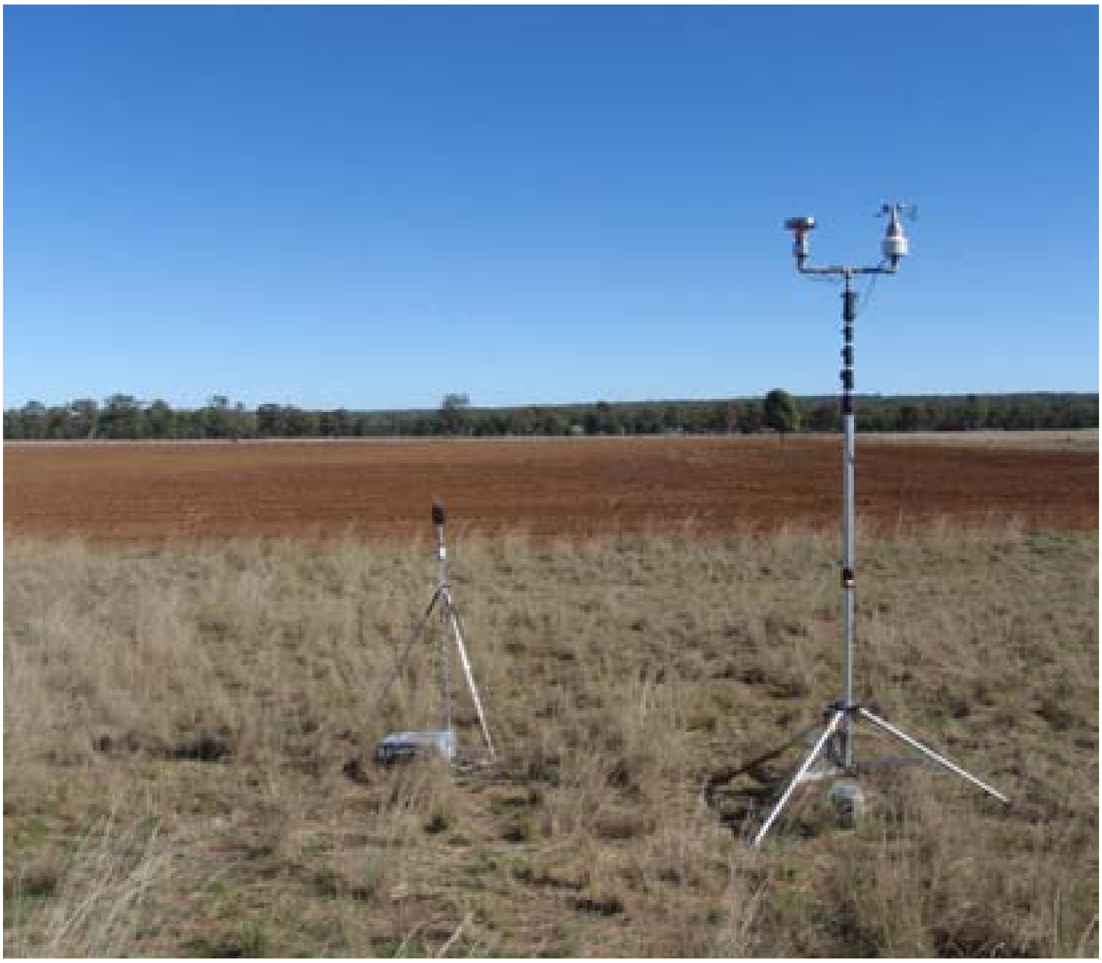


Figure 2: Example noise and meteorological monitoring instrumentation

Figure 3: Example drill rig – collar drive

Figure 4: Example drill rig – top drive

Figure 5: 50kW sound-attenuated Oil-lift well-head power supply

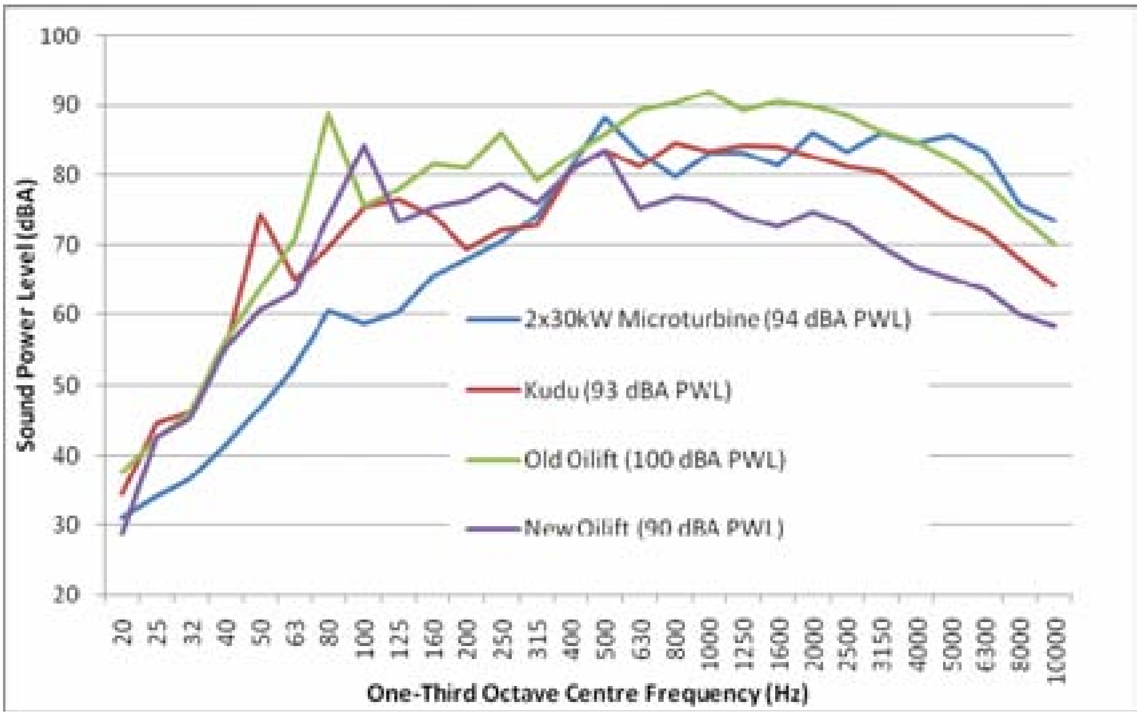



Figure 6: Comparative well drive sound power levels

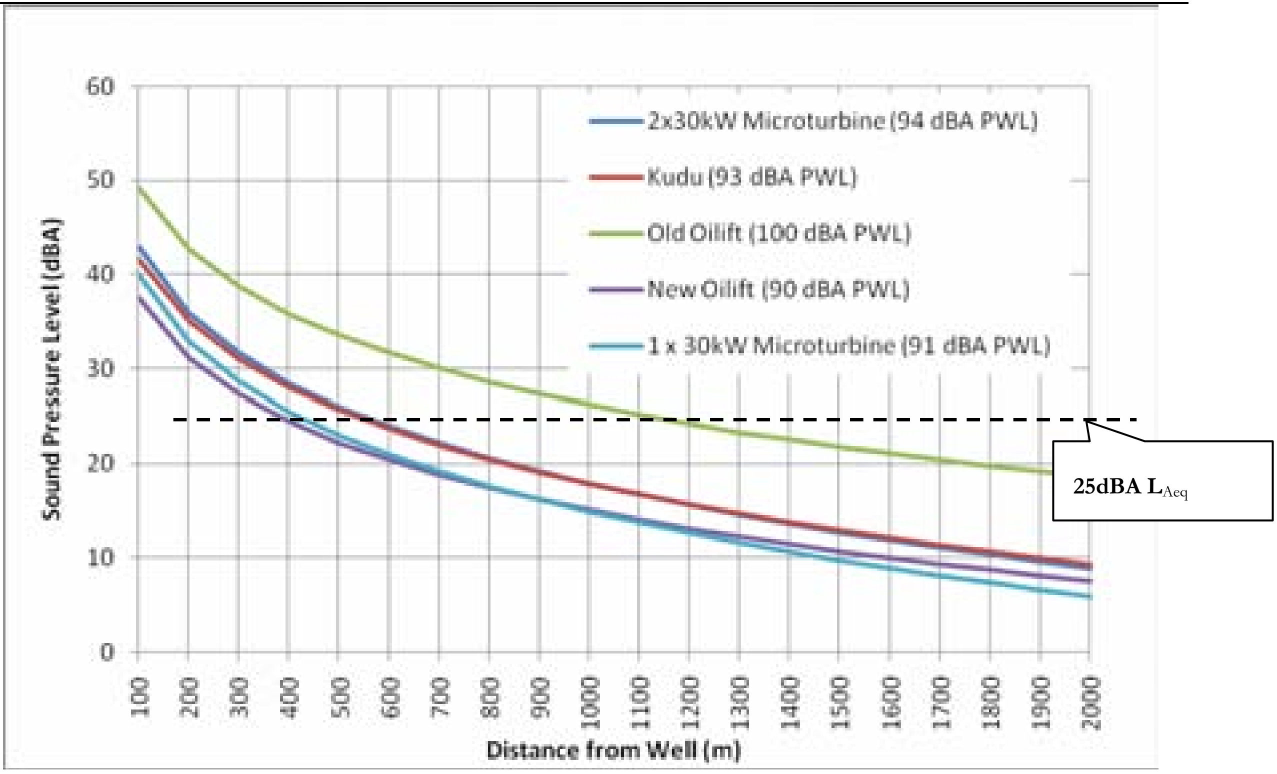



**Figure 7: Comparative well drive sound pressure levels versus distance**

**Figure 8: 60 TJpd gas processing facility (Spring Gully)**

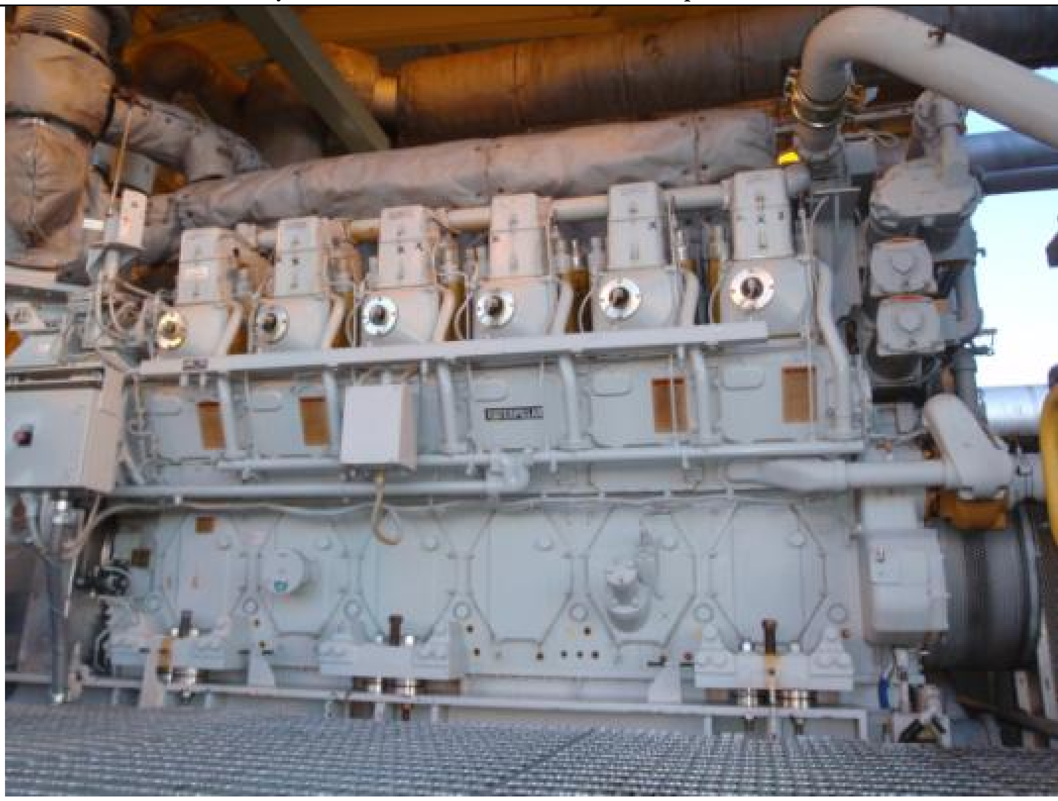


Figure 9: Example reciprocating gas engine (G3616 Spring Gully)

Figure 10: Example reciprocating gas compressor (Spring Gully)

Figure 11: Example screw gas compressor (Rockwood)

Figure 12: Mechanical fan cooler (Harsco Model 143 F4)

Figure 13: GPF flare (one compressor shutdown – Spring Gully)

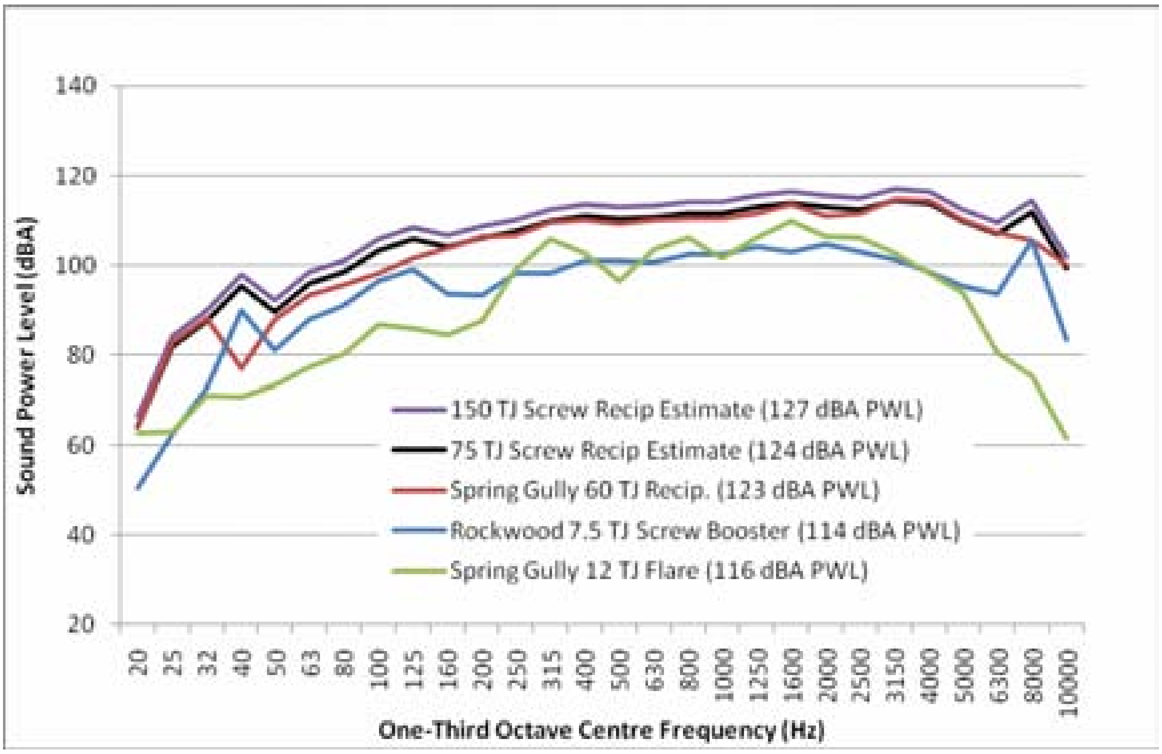



Figure 14: GPF sound power levels

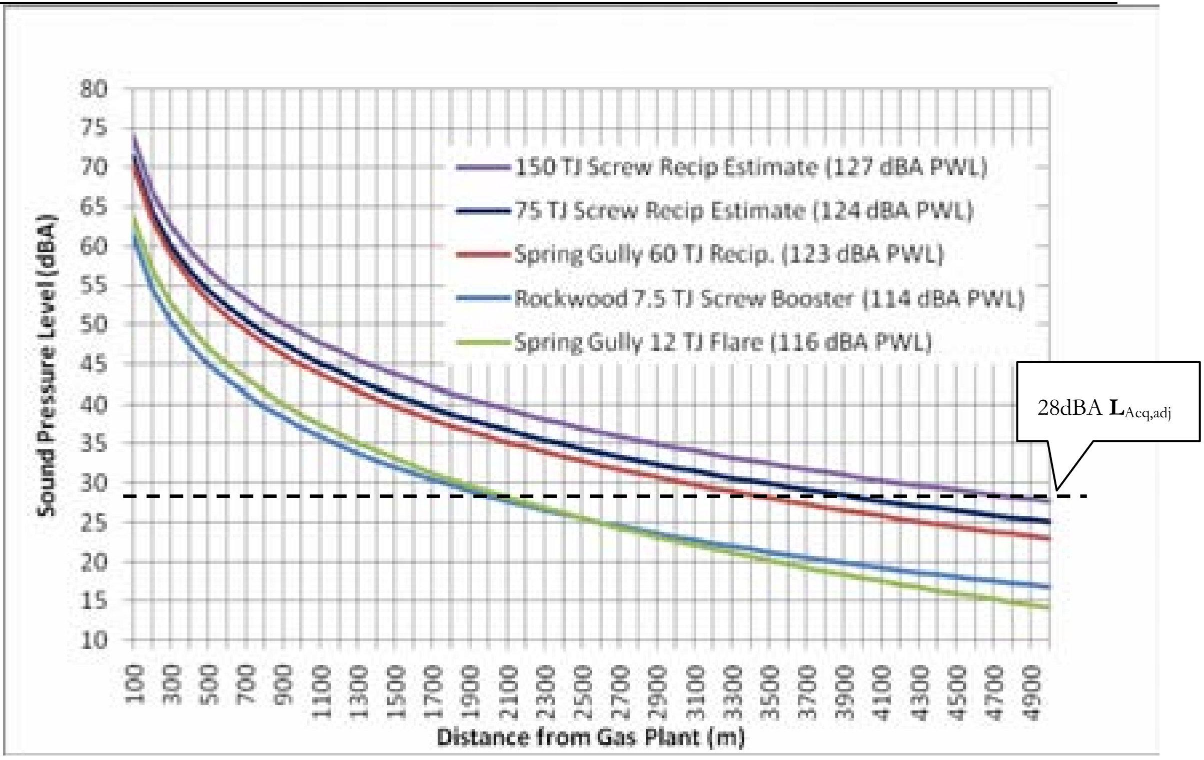



**Figure 15: GPF sound pressure levels versus distance**

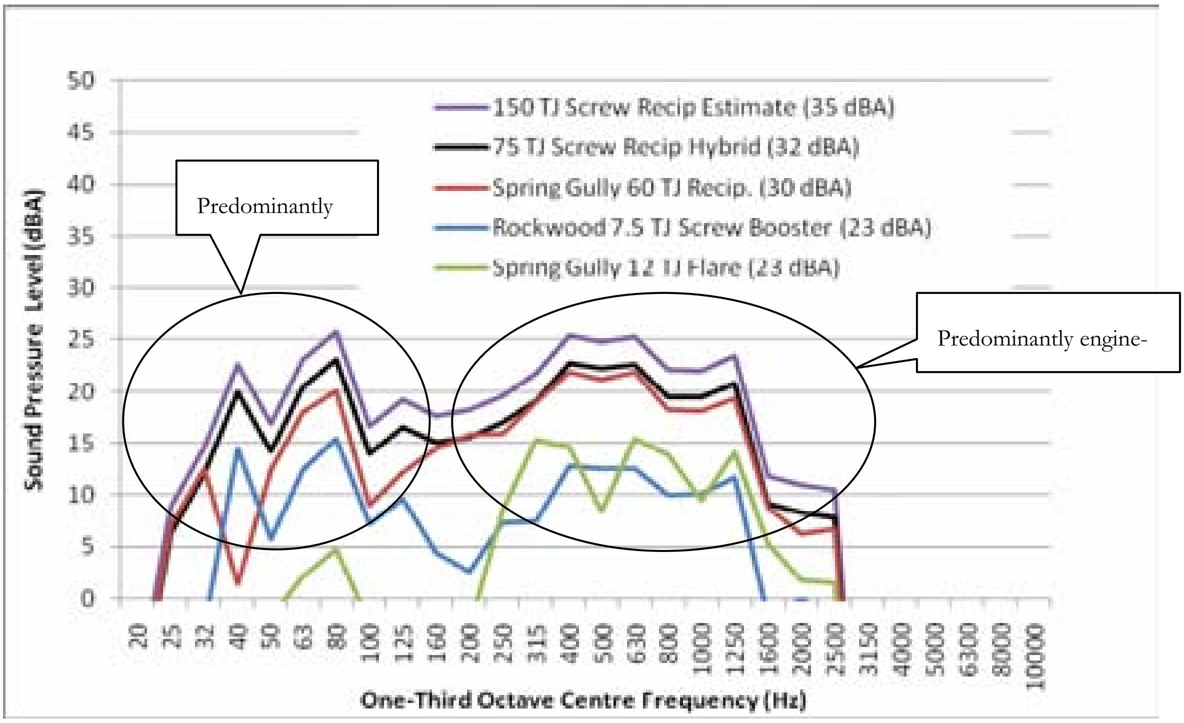



**Figure 16: GPF sound spectra at example 3km distance**

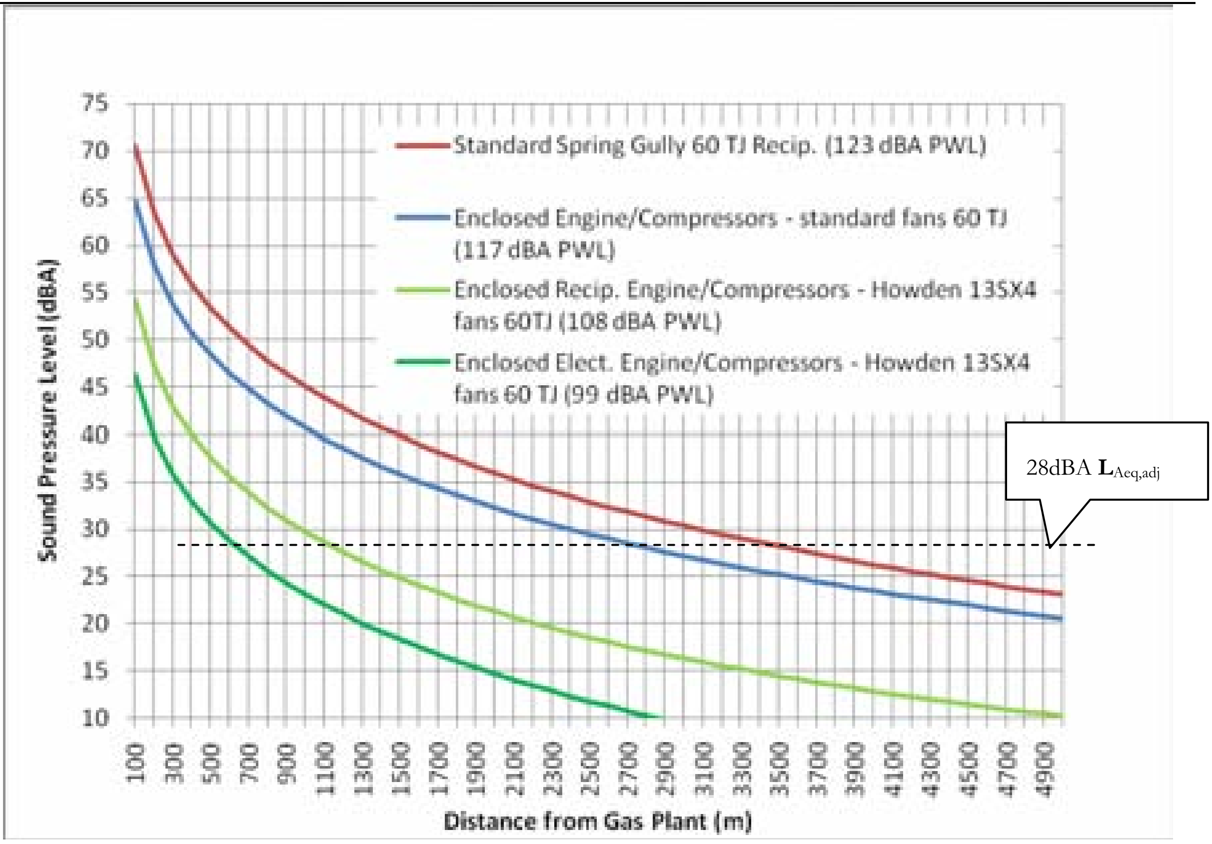



**Figure 17: Effect of enclosures and technologies on GPF noise dispersion**

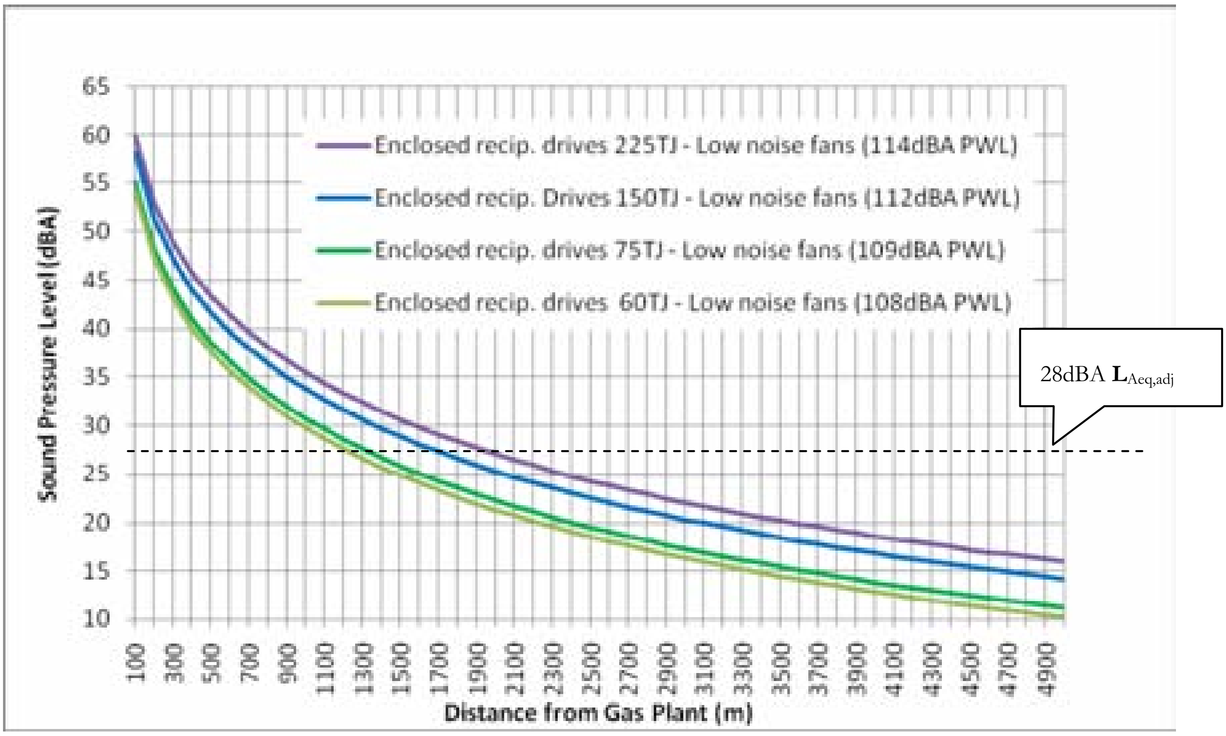



**Figure 18: Effect of GPF size on noise dispersion for proposed low-noise case**


**Figure 19: Water treatment facility outdoors(Spring Gully)**

**Figure 20: Water treatment facility indoors (Spring Gully)**

Figure 21: Power generation for WTF (Spring Gully)

Figure 22: Water transfer pumps (Spring Gully)

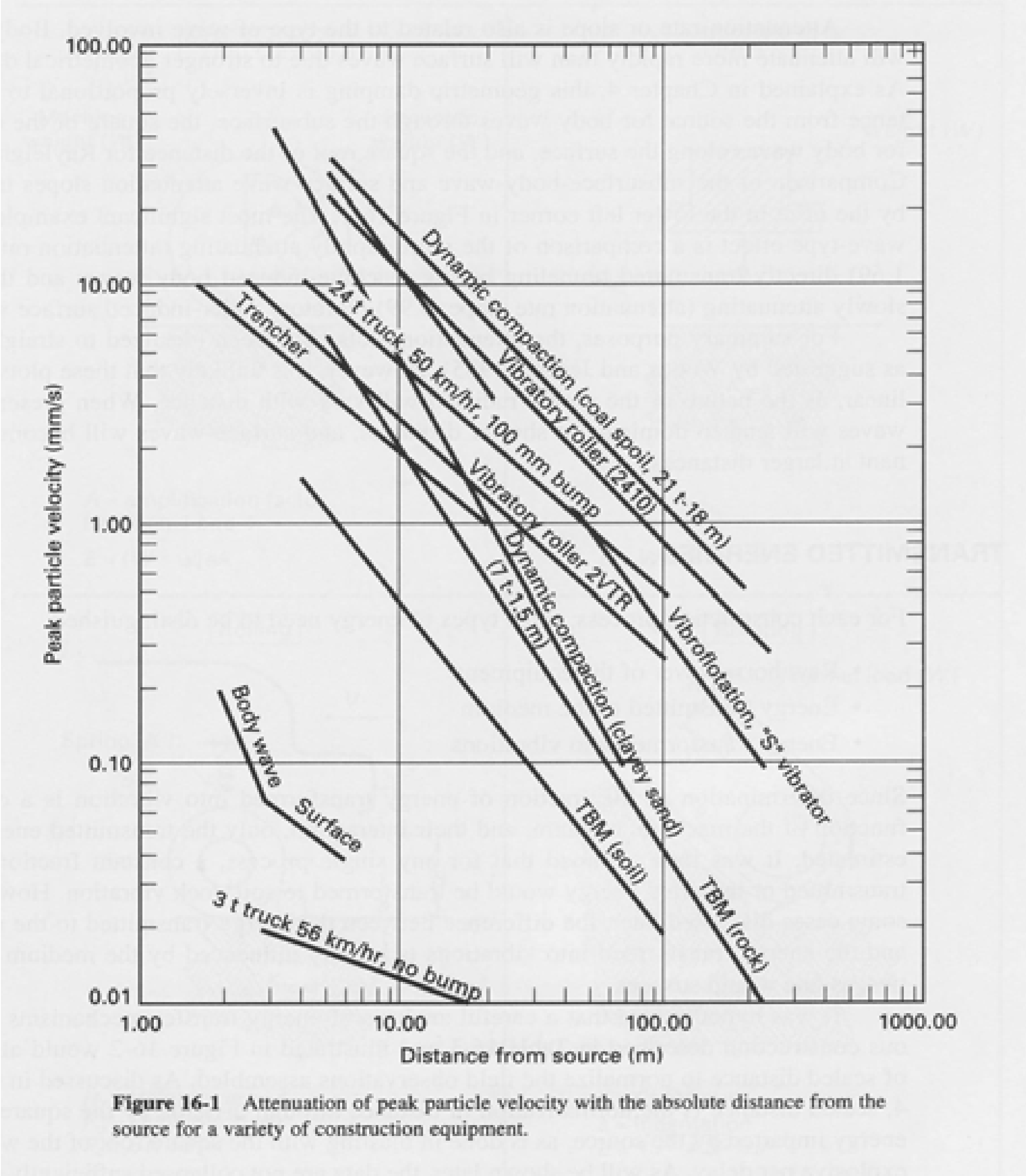



**Figure 23: Attenuation of ground vibration with distance from mechanical equipment (source: p247 Construction Vibrations – C H Dowding 2000)**

# Appendix A – Derivation of planning noise levels

## A.1 Control of background noise creep

To prevent the background noise levels (for day, evening and night periods) from gradually increasing with the establishment of new developments in an area, the guideline describes a methodology for determining the design emission limits for each new development (or industry) based upon 'recommended' and 'rating' (existing) outdoor background noise levels (min $L_{A90,\ 1hour}$[2] ). The recommended background noise levels depend upon the nature of the surrounding land use, being lower for green-field areas, and higher for recognised industrial areas, as detailed in Table 16.

**Table 16: Queensland DERM guideline - recommended background levels**

| Receiver land use | Receiver area dominant land use | Recommended background noise level minL$_{A90,1hour}$ (dBA)[27] Day (7am to 6pm) | Evening (6pm to 10pm) | Night (10pm to 7am) |
|---|---|---|---|---|
| Purely residential | Very rural | 35 | 30 | 25 |
| | Rural residential, church, hospital | 40 | 35 | 30 |
| | Shop or commercial office | 45 | 40 | 35 |
| | Light industry | 50 | 45 | 40 |
| Residential area on a busy road, or near an industrial or commercial area | Rural residential, church, hospital | 45 | 40 | 35 |
| | Shop or commercial office | 50 | 45 | 40 |
| | Light industry | 55 | 50 | 45 |
| Industrial area | Rural residential, church, hospital | 50 | 45 | 40 |
| | Shop or commercial office | 55 | 50 | 45 |
| | Factory office or factory | 60 | 60 | 60 |
| Passive recreation area | Picnic grounds, public beaches, bush walks, public gardens, etc. | 35 | 35 | 35 |

To control and prevent cumulative increase of the rating (actual) background level above the recommended background levels in Table 16, the Planning background levels (min$_{LA90,\ 1hour}$) applicable for a new development are determined from the recommended background levels (from Table 16) and the rating (existing) background levels in accordance with Table 17.

[27] minL$_{A90,1hour}$ is defined as the rating background level in accordance with the methodology defined in the Planning for Noise Control guideline

**Table 17: Queensland DERM guideline- planning background levels**

| Classification of rating background level at receptor | Planning background level ($minL_{A90,\ 1\ hour}$) |
|---|---|
| A. above the recommended level in Table 16 | At least 10dBA below Table 16 recommended level |
| B. at recommended level | 10dBA below Table 16 recommended level |
| C. below recommended level by: | Set planning background level: |
| 1dB | 9dB below recommended level |
| 2dB | 5dB below recommended level |
| 3dB | 3dB below recommended level |
| 4dB | 2dB below recommended level |
| 5dB | 2dB below recommended level |
| 6dB or more | 5dB above existing background level |

The planning equivalent noise level for a new development that is based upon consideration of background creep ($PNL_{Bg}$,) is determined using the planning background level ($minL_{A90,\ 1\ hour}$) from Table 17 in the following equation:

PNLBg, = Planning min.LA90,1 hour + 3 dB – K1 – K2

The adjustments (K1 and K2) are required by the guideline to account for tonal and impulsive noise characteristics of a development. If present, these characteristics increase the subjective audibility of sound and the resulting $PNL_{Bg}$, is lowered accordingly. The required adjustments to the $PNL_{Bg}$, to adjust for tonal and impulsive characteristics are summarised in Table 18.

**Table 18: Guideline corrections to $PNL_{Bg}$ for audible characteristics**

| Audible Characteristic | Criterion | Correction |
|---|---|---|
| Tonality | Subjectively just detectable | K1 = 2 - 3dB |
| | Subjectively prominent (clearly audible)[28] | K1 = 5 - 6 dB |
| Impulsivity | Subjectively detectable[29] | K2 = 2 dB |

[28] The objective test of tonality is as per AS1055.1 Clause 6.6.3

[29] The objective test of impulsive characteristics is as per AS1055.1 Clause 6.6.4

Planning equivalent levels ($PNL_{Bg}$,) have been determined in accordance with the methods of the guideline for the three typical baseline noise environments, based upon the ambient noise monitoring data presented in Section 4.0.

The analysis for sites described as 'Night RBL < 15', typified by site 9, is presented in Table 19. This area is considered to be 'very rural' with a night-time recommended RBL of 25dBA for a residential receiver.

The analysis for sites described as 'Night RBL = 16, within 1km of a major transport corridor', typified by site 14, is presented in Table 20. This area is considered to be 'very rural' with a night-time recommended RBL of 25dBA for a residential receiver.

It is conceivable that tonal characteristics could be significant for some combinations of plant and separation distance, given the low background noise levels prevailing throughout the study area. However, it is not possible to generally pre-determine the tonal or impulsive noise characteristics that may be discernible at any receptor locations in the manner that is suggested by the guideline[30]. Accordingly no penalties are recommended in the derivation of $PNL_{Bg}$ values for receptor locations. The resultant PNLs should therefore be expressed as an adjusted equivalent continuous A-weighted sound pressure level ($L_{Aeq\ 1\ hour,adj}$) so that suitable penalties can be applied to specific situations.

**Table 19: $PNL_{Bg}$ derivation for RBL < 15 dBA (no transportation noise)**

| Parameter | Source | Sound pressure level (dBA) | | |
|---|---|---|---|---|
| | | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
| Recommended background ($minL_{A90,1\ hour}$) | Table 16 | 35 | 30 | 25 |
| Rating background ($minL_{A90,1\ hour}$) | Site 9 | 20 | <15 | <15 |
| Planning background ($minL_{A90,1\ hour}$) | Table 17 | 25 (Rating+5) | 20 (Rating+5) | 20 (Rating+5) |
| Planning noise level ($PNL_{Bg}$,) ($L_{Aeq,1hour,adj}$) | Planning background + 3 | 28 | 23 | 23 |

[30] For other projects, the presumption of a tonal correction in deriving the PNLs has caused confusion in the specification of licensed levels. It is more appropriate and accurate that the determination of adjustments for tonal and impulse corrections is performed when emissions from a specific source at a given distance are assessed.

**Table 20: $PNL_{BG}$ derivation for RBL = 16 dBA (≤ 1 km to transport corridor)**

| Parameter | Source | Sound pressure level (dBA) | | |
|---|---|---|---|---|
| | | **Day** (7am – 6pm) | **Evening** (6pm – 10pm) | **Night** (10pm – 7am) |
| Recommended background ($minL_{A90,1\ hour}$) | Table 16 | 35 | 30 | 25 |
| Rating background ($minL_{A90,1\ hour}$) | Site 14 | 27 | 17 | 16 |
| Planning background ($minL_{A90,1\ hour}$) | Table 17 | 32 (Rating+5) | 22 (Rating+5) | 21 (Rating+5) |
| Planning Noise Level ($PNL_{Bg,}$) ($L_{Aeq,1hour,adj}$) | Planning background + 3 | 35 | 25 | 24 |

### A.2 Management of variable noise

To ensure that the derived PNL adequately contains levels of transient or variable noises from new developments (e.g. transportation noise or noise from cyclic industrial processes), the guideline describes a methodology for determining an alternative PNL. This methodology depends on the relationship between the baseline minimum $L_{Aeq,1hour}$ values in each time period and the recommended maximum PNLs advised in the guideline. The guideline advises that the recommended maximum PNLs are intended to help protect against impacts such as "speech interference, community annoyance and, to some extent, sleep disturbance".

The guideline recommended maximum PNLs depend upon the nature of the surrounding land use, being lower for green-field areas and higher for recognised commercial/industrial areas and areas with more transportation noise sources, as defined in Table 21.

**Table 21: Guideline recommended maximum PNLs**

| Noise area category | Description of neighbourhood[31] | Recommended maximum PNL[32], ($L_{Aeq,1hour}$ - dBA) |
|---|---|---|

[31] Where transportation noise is present, the minimum of the hourly $L_{Aeq}$ values for transportation noise in the appropriate time period is taken, or the corresponding guideline value from Table 21, whichever is the greater. Guidance in selecting the appropriate hourly $L_{Aeq}$ values for premises adjoining roadways carrying more than 100 vehicles/hour is given in the guideline.

[32] Recommended levels are estimated 4m from the facade of a building.

| | | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
|---|---|---|---|---|
| Z1 | Very rural, purely residential. Less than 40 vehicles/hour | 40 | 35 | 30 |
| Z2 | Negligible transportation. Less than 80 vehicles/hour | 50 | 45 | 40 |
| Z3 | Low-density transportation. Less than 200 vehicles/hour | 55 | 50 | 45 |
| Z4 | Medium density transportation (less than 600 vehicles/hour) or some commerce or industry | 60 | 55 | 50 |
| Z5 | Dense transportation (less than 1200 vehicles/hour) or some commerce or industry | 65 | 60 | 55 |
| Z6 | Very dense transportation (less than 3000 vehicles/hour) or in commercial or bordering industrial districts | 70 | 65 | 60 |
| Z7 | Extremely dense transportation (3000 or greater vehicles/hour) or within predominantly industrial districts | 75 | 70 | 65 |

The procedure for determining the $PNL_{Eq}$ considers both the 'baseline' minimum $_{LAeq,1hour}$ values and the maximum recommended PNLs, as summarised in Table 22.

**Table 22: Guideline determination of $PNL_{Eq}$ to contain variable noise**

| Comparison of baseline $L_{Aeq,1hour}$ at receptor with recommended PNL (Table 21) | $PNL_{Eq}$ for new sources ($L_{Aeq,\,1\,hour}$ – dBA) |
|---|---|
| Baseline ≥ Recommended + 2 dB | If baseline $L_{Aeq,1hour}$ is likely to decrease in future, 10 dB below recommended PNL<br>If baseline $L_{Aeq,1hour}$ is likely to increase in future, 10 dB below baseline PNL |
| Baseline = Recommended + 1 dB | Recommended – 9 dB |
| Baseline = Recommended | Recommended – 8 dB |
| Baseline = Recommended -1 dB | Recommended – 6 dB |
| Baseline = Recommended -2 dB | Recommended – 4 dB |
| Baseline = Recommended -3 dB | Recommended – 3 dB |
| Baseline = Recommended -4 dB | Recommended – 2 dB |
| Baseline = Recommended -5 dB | Recommended – 2 dB |
| Baseline = Recommended -6 dB | Recommended – 1 dB |
| Baseline < Recommended -6 dB | Recommended |

### A.3 Design PNL

After determining the $PNL_{Eq}$ and $PNL_{Bg}$, these values are compared and the lower value used as the design PNL ($PNL_{Design}$). This analysis is summarised for the representative scenarios as follows:

- Table 23, Night RBL < 15dBA (remote from transport corridors, e.g. site 9)
- Table 24, Night RBL = 16dBA (within 1000m of major transport corridors, e.g. site 14)

In all instances considered, the design PNL equates to $PNL_{Bg}$.

### Table 23: Design PNL derivation for RBL < 15dBA (no transportation noise)

| Parameter | Source | Sound pressure level ($L_{Aeq,1hour}$ – dBA) | | |
|---|---|---|---|---|
| | | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
| Recommended maximum PNL | Table 21 (z1) | 40 | 35 | 30 |
| Baseline minimum $L_{Aeq,1hour}$ | Site 9 | 35 | 21 | 16 |
| $PNL_{Eq}$ ($L_{Aeq,1hour}$) | Table 22 | 38 (Recommended-2) | 35 (Recommended) | 30 (Recommended) |
| $PNL_{Bg}$ ($L_{Aeq,1hour}$) | Table 19 | 28 | 23 | 23 |
| $PNL_{Design}$ ($L_{Aeq,1hour}$) | Lesser of $PNL_{Eq}$ and $PNL_{Bg}$ | 28 | 23 | 23 |

### Table 24: Design PNL derivation for RBL = 16 dBA (≤ 1 km to transport corridor)

| Parameter | Source | Sound pressure level ($L_{Aeq,1hour}$ – dBA) | | |
|---|---|---|---|---|
| | | Day (7am – 6pm) | Evening (6pm – 10pm) | Night (10pm – 7am) |
| Recommended maximum PNL | Table 21 (z1) | 40 | 35 | 30 |
| Baseline minimum $L_{Aeq,1hour}$ | Site 14 | 38 | 35 | 27 |
| $PNL_{Eq}$ ($L_{Aeq,1hour}$) | Table 22 | 36 (Recommended-4) | 27 (Recommended - 8) | 27 (Recommended-3) |
| $PNL_{Bg}$ ($L_{Aeq,1hour}$) | Table 20 | 35 | 25 | 24 |
| $PNL_{Design}$ ($L_{Aeq,1hour}$) | Lesser of $PNL_{Eq}$ and $PNL_{Bg}$ | 35 | 25 | 24 |

# Appendix B – Glossary of acoustic terminology

**Auditory frequency range**

A frequency range in which sounds are potentially perceivable by humans, often reported as 20 Hertz – 20 kiloHertz (1 Hertz = 1 cycle per second).

**Airblast overpressure**

A measure of the transient air-pressure pulse generated by a blast. Units of un-weighted peak pressure, expressed as a decibel level referenced to 20 microPascals ($L_{peak}$).

**Ambient noise level**

Concept of the all-encompassing noise level environment at a location of interest. A full description of the ambient noise level includes description of level variations in time and variations in the frequency composition in time, including subjective audible characteristics.

**Background noise level ($L_{Abg}$)**

Concept of the typical minimum ambient noise level, numerically evaluated[33] from the level exceeded for 90 percent of 15 minute sample periods ($L_{A90,15\ minute}$) during a defined time period of interest (e.g. daytime, evening or night-time).

**Baseline noise level**

Concept of the noise level prior to a development, that can be evaluated by a range of level parameters such as the minimum ($L_{Amin}$), maximum ($L_{Amax}$) and percentile descriptors ($L_{A1,}$ $L_{A10,}$ $L_{Aeq}$, $L_{A90}$)

**Broadband noise**

A noise with approximately equal acoustic energy distribution over a large range of frequencies, for example 100 Hz – 2 KHz. Natural examples include noise from a waterfall, or the sound of wind in trees.

**Construction/blast vibration**

Transient oscillating movement of the ground or a building structure from transmission of elastic pressure waves from the vibration source, through the ground to the receptor location

**Far-field**

A distance defined to be so far from the noise source that the source can be treated as a point source.

**Hydrophone**

A microphone designed to be used underwater for recording or listening to underwater sound.

**RMS** (root-mean-square) sound pressure

[33] By AS1055 this evaluation is by averaging the $L_{A90,15minute}$ values. By the DERM Planning for noise control guideline this evaluation is more complex, taking the 90th percentile of the $L_{A90,15minute}$ values relevant to the day, evening and night periods on a given day, and then taking the median of the daily results over a minimum seven day period.

Mathematical averaging process for the rapid positive and negative acoustic pressure cycles (relative to atmospheric pressure) that constitutes sound, to define a positive equivalent pressure level relative to atmospheric pressure with the same energy as the cyclical quantity. (because the RMS pressure is a time averaged quantity, it cannot indicate the peak instantaneous pressure such as may be relevant to assessing risk of bursting an ear-drum, as an example)

**Sound**

Sound consists of small air-pressure fluctuations or pressure waves. The human auditory system responds to both the intensity (pressure-wave amplitude) of a sound and the frequency (number of pressure cycles per second) of a sound. These pressure fluctuations travel along the ear canal and vibrate the ear-drum. The vibrations of the ear-drum are transmitted via the middle-ear to the inner ear where the intensity and frequency are coded into electrical signals for interpretation by the brain. This allows a person to sense the 'pitch' and 'loudness' of a sound.

**Statistical acoustic parameters for environmental noise assessment**

Common noise sources, such as industrial processes, transportation (cars, trucks, trains), natural noise (wind in trees, birds, insects), vary with time. Therefore, during a measurement period of duration 'T', it is important to define whether the maximum, minimum, average or a percentile statistical level is being specified.

In a quiet rural area, for example, the maximum sound pressure level for a fraction of a second may be 80dBA from a nearby bird call, whereas the minimum sound pressure level between bird calls, and when the trees are still, may be 20dBA. Without statistical definition, the level range of 20dBA to 80dBA would be confusing.

The following sound level parameters are used to describe the 'prevalence' of the acoustic environment at different sound pressure levels (all fast response, A-weighted, RMS sound pressures levels relative to a 20μPa reference pressure):

- $L_{Amax,T}$ –the maximum level in time interval 'T'
- $L_{Amin,T}$–the minimum level in time interval 'T'
- $L_{Aeq,T}$ – the theoretical constant level with the same sound energy as the actual fluctuating level in a time interval 'T'
- $L_{A1,T}$ – the level exceeded for 1 percent of time interval 'T'
- $L_{A10,T}$ – the level exceeded for 10 percent of time interval 'T'
- $L_{A90,T}$ – the level exceeded for 90 percent of time interval 'T', often termed the 'background' level.

**One-third-octave spectrum**

The frequency content of a noise is described by a frequency spectrum. A frequency spectrum can be expressed as a one-third-octave spectrum, which, instead of displaying every frequency individually, is comprised of sub-frequency ranges centred at the following frequencies, measured in Hertz (1 Hertz = 1 cycle per second):

20,25,31.5,40,50,63,80,100,125,160,200,250,315,400,500,630,800,1000,1250, etc.

**Planning noise level (PNL)**

Nomenclature specific to the DERM Ecoaccess guideline 'Planning for noise control' defining the permissible noise contribution from a proposed facility at a defined receptor

**Rating background noise level (RBL)**

Nomenclature specific to the DERM Ecoaccess guideline 'Planning for noise control' defining the background noise level from $L_{A90,15miute}$ levels during the day, evening and night over a minimum seven day period.

**Response time**

The human auditory system has a certain delay in responding to noise. For extremely 'fast' sources of noise, such as a gun-shot at the ear of the firer, the increase in sound is so rapid that the hearing system is unable to respond quickly enough for the protective muscular reflex of the ear-drum to operate.

Sound level meters are designed to emulate the 'response-speed' of the human auditory system. This is conventionally described as the 'fast response' sound level meter response setting.[34]

**Sensitive receptor**

A place that may be sensitive to additional noise associated with a proposed development

**Sensitivity to sound frequency**

At any instant the acoustic environment contains a complex mix of sound components at different frequencies and at different levels. A person speaking, for example, will simultaneously produce vowel sounds typically in the range of 250Hertz to 1kiloHertz, and higher frequency sounds associated with consonants, such as 'hisses' and 'clicks', in the range of 2kiloHertz to 8kiloHertz.

Human hearing has the greatest 'sensitivity' to sound at frequencies in the range of 2kiloHertz to 4kiloHertz, with decreasing sensitivity at higher and lower frequencies. At 1kiloHertz, the sensitivity is only slightly lower (-1dB, or around 90% of optimal pressure sensitivity), whereas at 100Hertz the sensitivity is much lower (-19dB, or around 10% of optimal pressure sensitivity).

**Sensitivity to sound level**

Laboratory testing of the hearing of a large number of human subjects has been conducted by scientists to determine the 'threshold' of human hearing. This threshold is the quietest sound that can be just determined by the human ear under ideal (quiet) laboratory conditions. This nominal hearing threshold has been quantified as a root mean squared (RMS), or 'average' pressure fluctuation of 0.00002 Pascals or 20 microPascals (20μPa).

The upper limit of human hearing for sounds of short duration is an RMS pressure fluctuation of around 20Pascals (20Pa). Above this level, the auditory system is rapidly unable to translate information about level and frequency.

To provide a more manageable scale for the wide numerical range of sound pressures that the human ear is able to respond to (i.e. 0.00002Pa to 20Pa), it is conventional to

[34] Objective measures of gun-shot noise or other explosive events, in the context of hearing damage potential, use a peak sound pressure level detection to ensure that the actual maximum sound pressure impacting on the human subject is known.

define a 'sound pressure level' as the ratio of a given sound pressure (p) relative to the human threshold of hearing ($p_{ref}$ = 20μPa RMS) as follows:-

$$\text{Sound pressure level, } L_p = 10*\log_{10}(p^2/p_{ref}^2)$$

With this definition, the nominal threshold of hearing becomes zero decibels (or 0dB), and the maximum, clearly audible level becomes 120dB, referenced to 20μPa.

0 dB equates to the quietest level of introduced sound that a person with healthy hearing can detect in a much quieter laboratory. A level of 120dB might be experienced close to speakers at a loud rock concert, or near an industrial nailing gun. Two people standing a metre apart and conversing might speak at levels that are about 50dB to 60dB.

Laboratory studies have found that a 10dB increase in a sound is perceived as approximately doubling in loudness. Conversely, a 10dB decrease in a sound is perceived as halving in loudness.

**Sound exposure level (SEL)**

The total sound energy produced by a noise event of interest, such as an aircraft flyover, a single pile strike, or the total sound exposure over a defined period such as an 8 hour working day, or 24 hour period.

**Sound level meters and A-weighting**

The sound level meter was invented to enable systematic investigation and study of sound that is of concern to humans. One of its tasks is to gauge the level of a sound as it may be perceived by the human ear. This is not easy as the human ear not only has different sensitivities depending on the frequency of sound, but the sensitivity also changes as the level of sound changes.

The 'A-weighting' system is an internationally agreed system of sensitivity adjustments to measured sound at frequencies ranging from 10Hz to 20kHz, enabling a sound level meter to approximate the sound level response of the human auditory system. A sound pressure level with an 'A frequency weighting' or A-weighting is an approximate gauge of the significance of a measured sound pressure level to the human ear.

A measured sound pressure level that incorporates A-weighting is denoted $L_{pA}$, and has units of dB(A), often written as dBA.

**Sound power**

The total sound radiated from a source per unit of time, expressed in decibels relative to 1 x $10^{-12}$ Watts.

**Threshold shift (temporary, TTS)**

Exposure to noise that causes the auditory system of a human or animal to temporarily lose some degree of sensitivity to sound, where the sensitivity is recovered after cessation of the noise exposure.

**Threshold shift (permanent, PTS)**

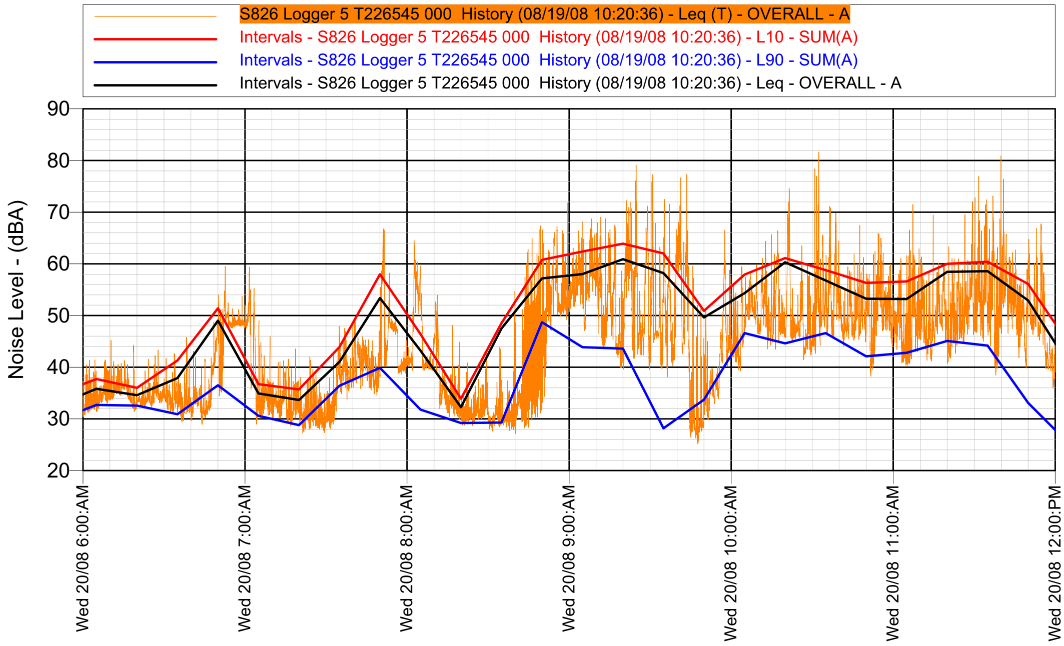
Exposure to noise that causes the auditory system of a human or animal to permanently lose some degree of hearing sensitivity. The sensitivity is not recovered after cessation of the noise exposure.

### Tonality and impulsivity adjustments to measured levels

The human brain tends to 'tune-in' to tones, sound patterns and rhythms to an extent that is not sufficiently reflected by the A-weight fast-response indication of a sound level meter. For example, a person is able to differentiate a distant siren sound from background noise before it will be apparent on an A-weight indicating sound level meter. Similarly, hearing is attuned to sounds that change rapidly in level, such as bangs and knocks, which are described as 'impulsive'. To account for these discrepancies between human sensitivity and sound level meter sensitivity, a 'tonal adjustment' or an 'impulse adjustment' to the measured level is defined.[35] A measured sound pressure level that has been adjusted to account for the increased audibility by virtue of its impulsive or tonal characteristics is denoted $L_{A,adj}$.

[35] The methodology for this adjustment is described in AS1055.1-1997 *Acoustics-Description and measurement of environmental noise Part 1: General Procedures*.

# Appendix C – Well Construction Noise Samples



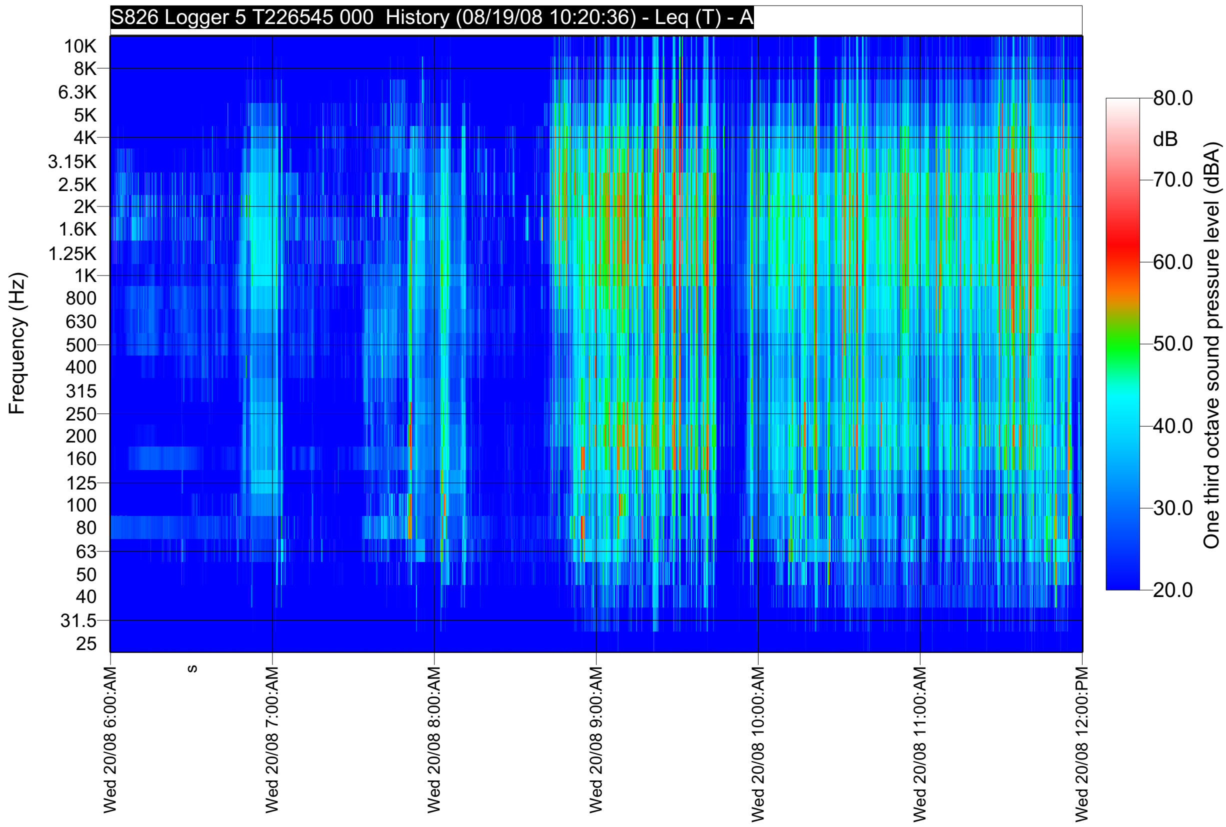




**Figure 24: Drill-rig setup - noise characteristics at 88m from well centre**

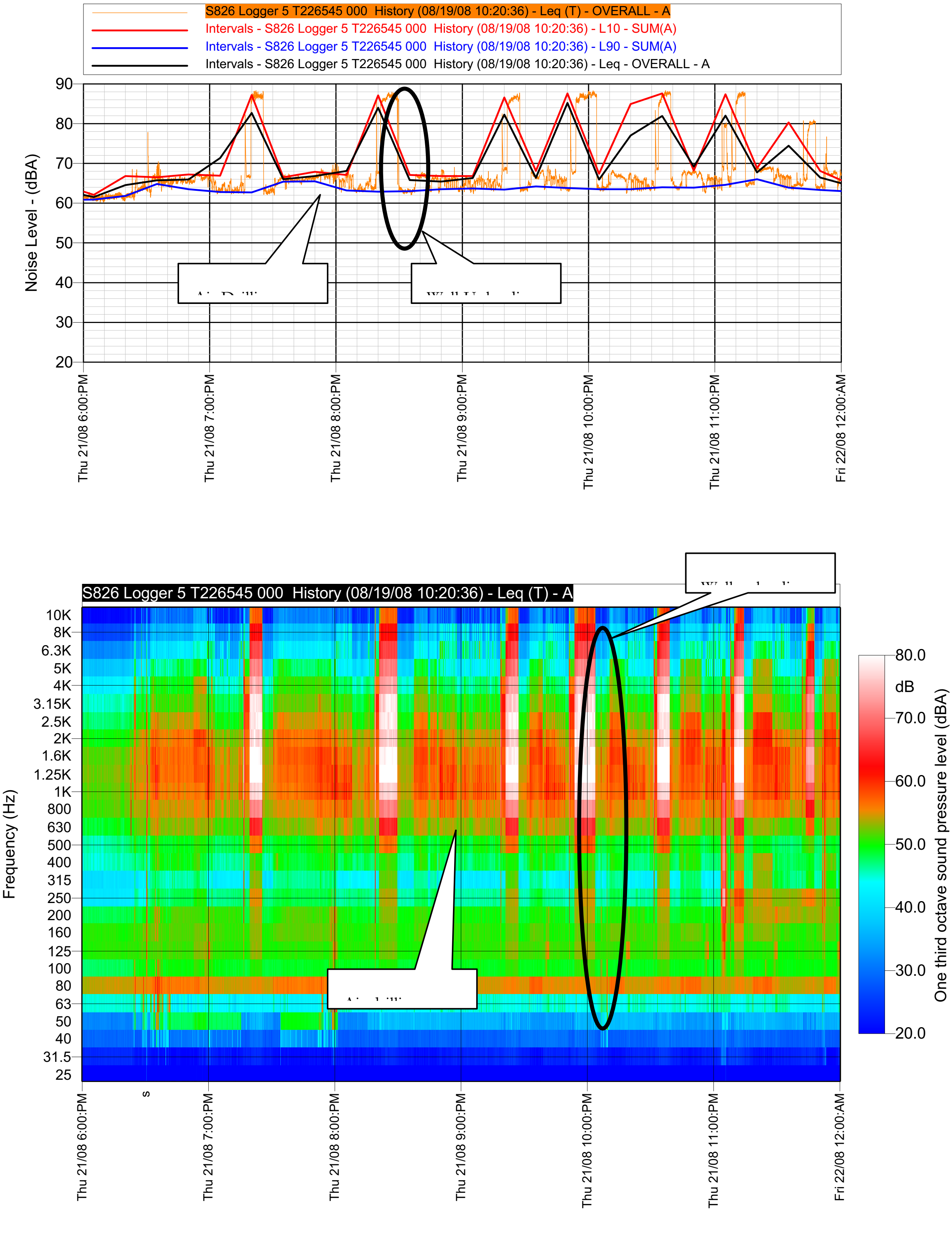
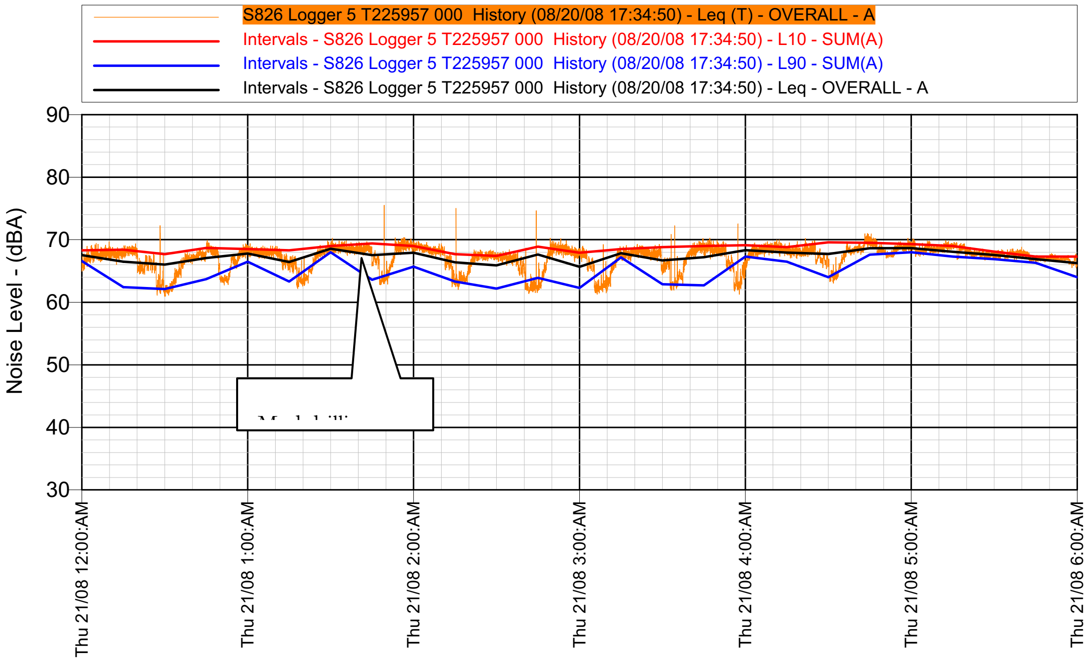



**Figure 25: Air-drilling and well-unloading cycles at 88m from well centre**



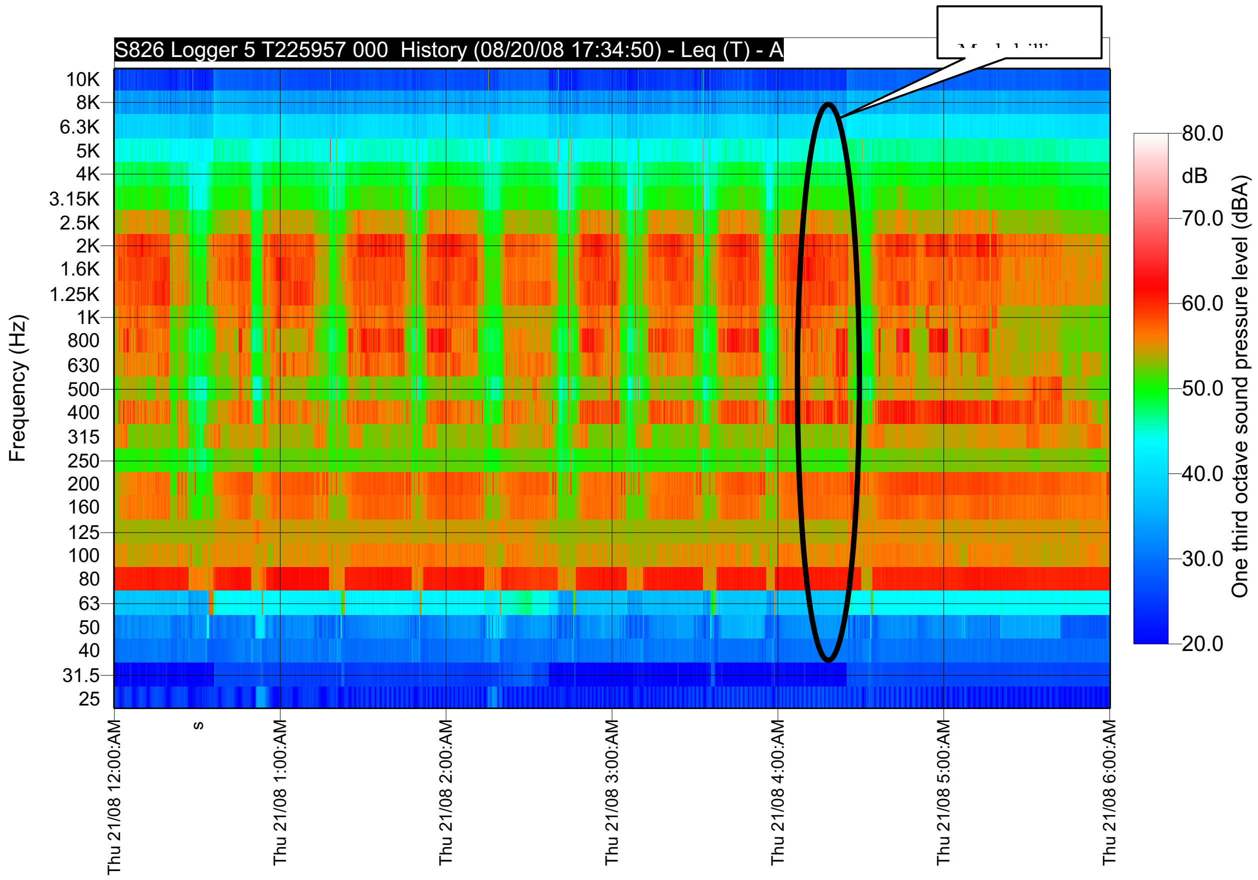
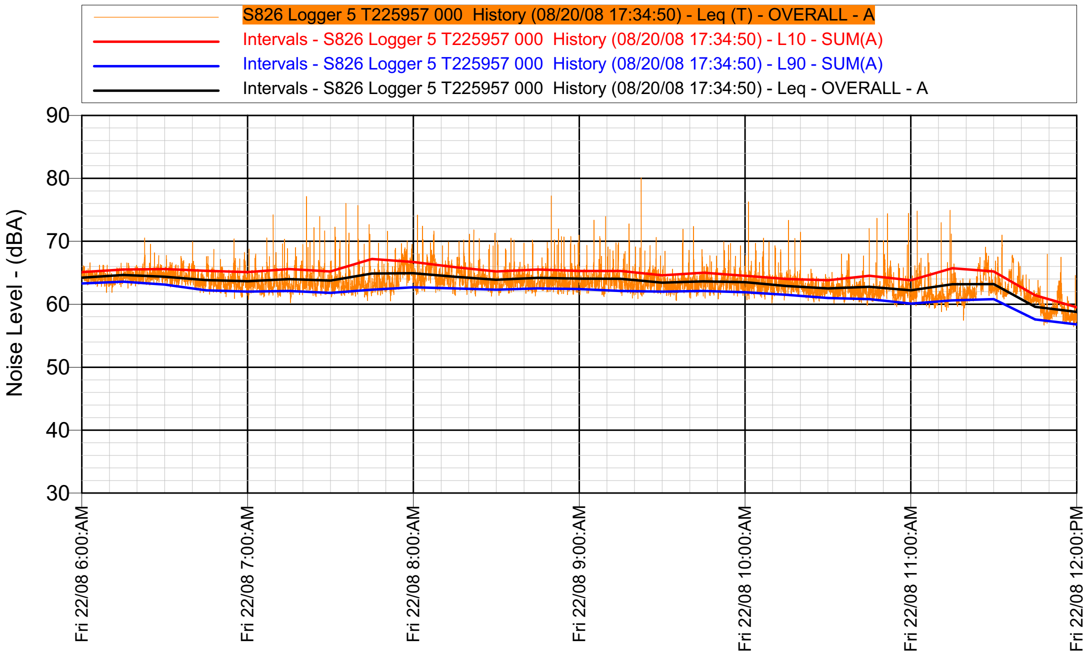




**Figure 26: Cyclic mud-drilling at 50m from well centre**



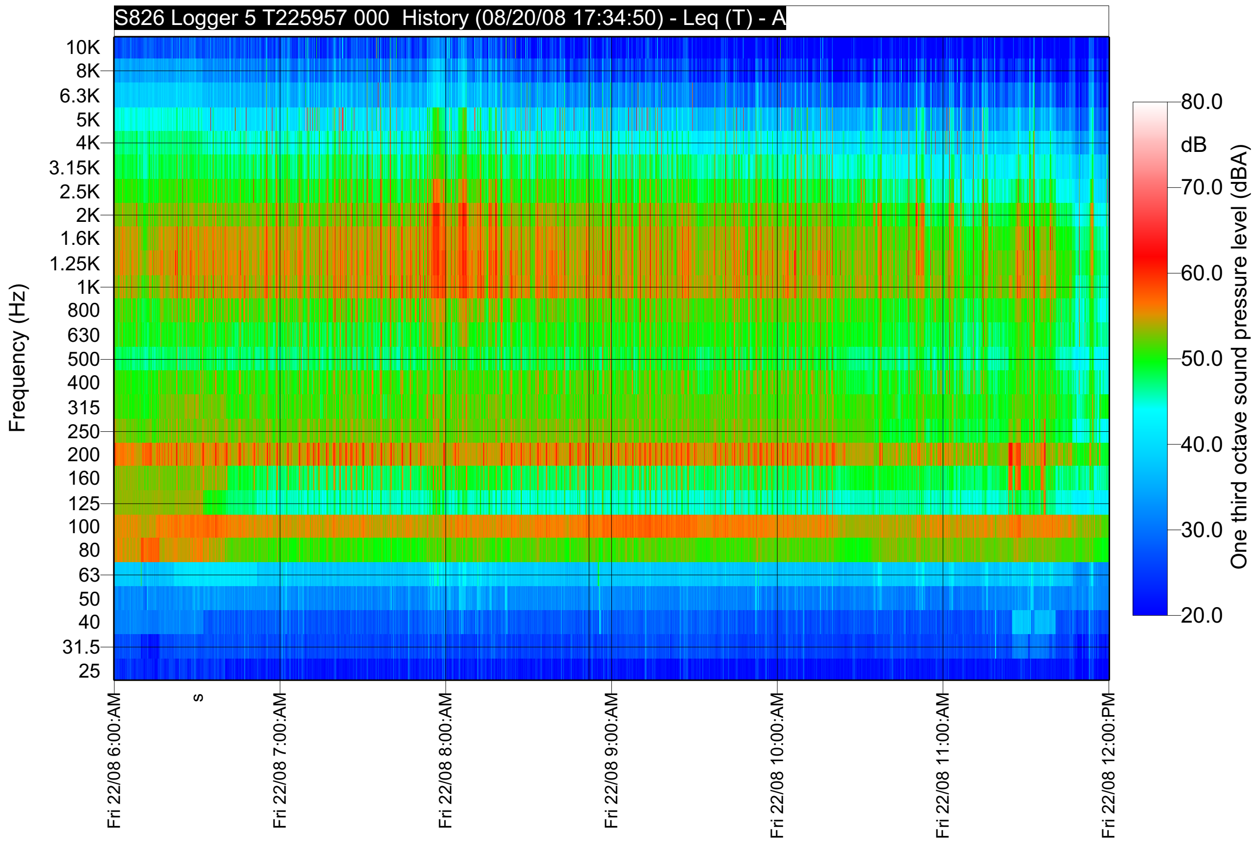
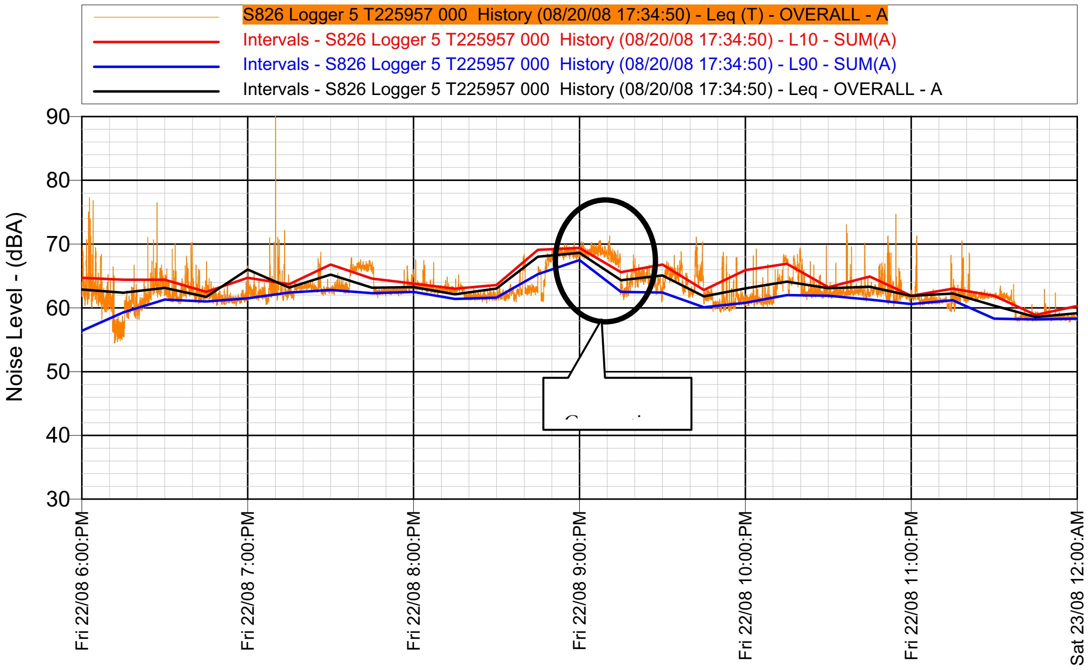




**Figure 27: Pulling drill-string from hole at 50m from well centre**



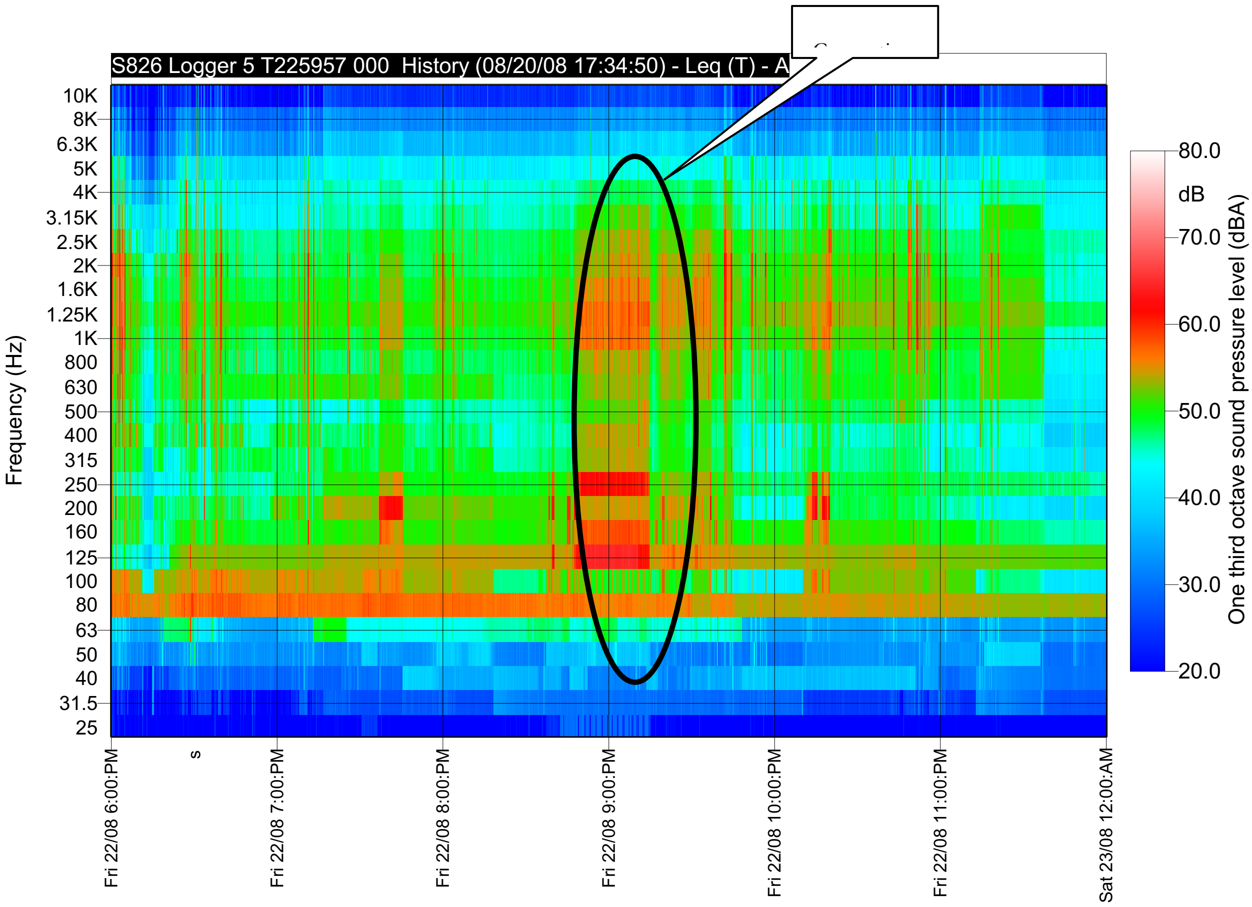
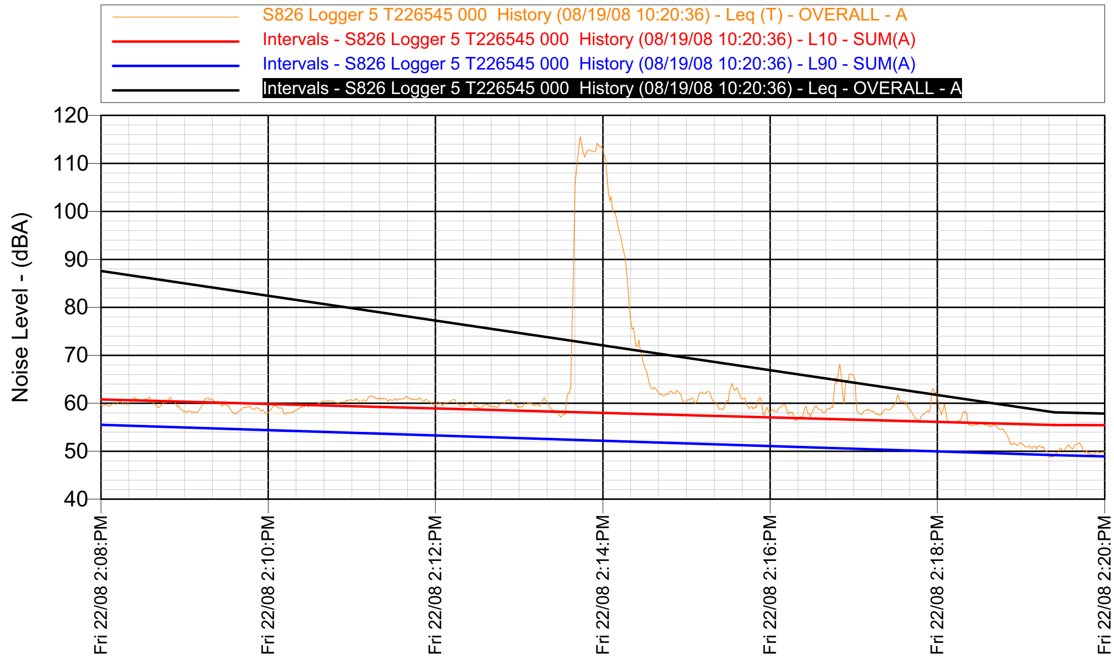




**Figure 28: Cementing rig and mud-drilling rig idling at 50m from well centre**



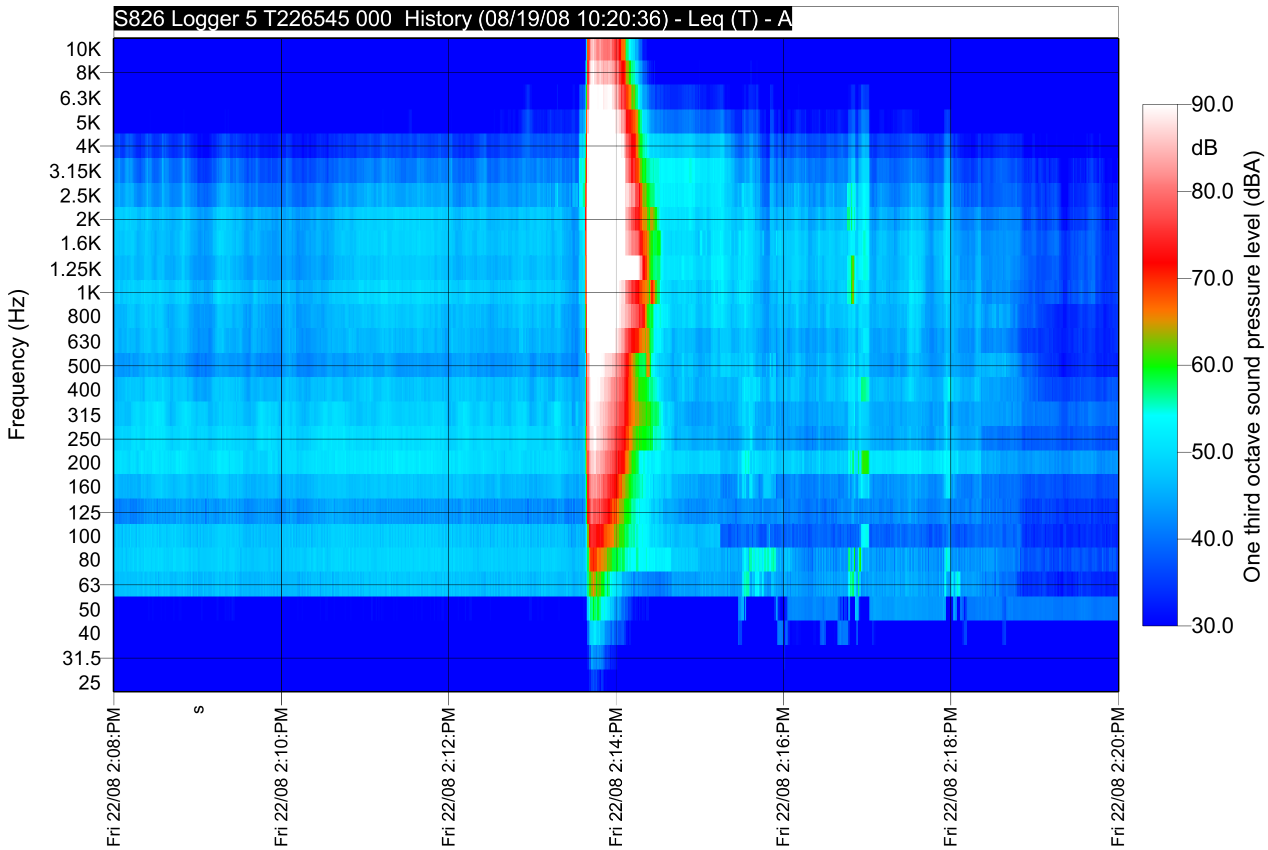




**Figure 29: cavitation noise @ 55m square of flare-line exit**

# Appendix D – Source noise data

## Table 25: Well construction sound power data

| Well Construction Activity | Octave Sound Power Data - dBA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k | Overall - dBA |
| **Drill Rig 1** | | | | | | | | | |
| Generator | 103.8 | 97.3 | 101.3 | 104.6 | 107.2 | 104.7 | 97.3 | 85.9 | 112.0 |
| Idle | 94.1 | 94.7 | 94.0 | 92.8 | 96.8 | 98.5 | 89.0 | 74.8 | 103.5 |
| Mud drilling | 104.6 | 102.7 | 102.3 | 104.6 | 107.2 | 105.3 | 96.7 | 82.5 | 112.7 |
| Mud-pump | 88.9 | 95.2 | 97.6 | 101.9 | 105.9 | 104.7 | 95.9 | 82.6 | 109.9 |
| Pulling-out running-in | 94.5 | 100.8 | 102.2 | 97.8 | 100.8 | 99.5 | 91.6 | 75.4 | 107.8 |
| Rig drive | 101.0 | 99.0 | 103.3 | 103.9 | 105.0 | 102.2 | 93.1 | 78.5 | 110.7 |
| Sullair engine/compressor | 91.9 | 101.8 | 105.6 | 107.3 | 110.9 | 108.4 | 101.9 | 99.6 | 115.1 |
| Well unloading | 98.6 | 101.9 | 103.0 | 106.3 | 113.1 | 115.5 | 117.6 | 116.2 | 122.2 |
| Cementing rig | 93.8 | 104.3 | 111.5 | 108.6 | 112.3 | 109.5 | 103.2 | 93.7 | 117.2 |
| **Drill Rig 2** | | | | | | | | | |
| Air drilling | 105.7 | 103.5 | 101.6 | 104.3 | 110.6 | 109.3 | 103.0 | 92.8 | 115.1 |
| Cavitation pump-up | 98.3 | 99.4 | 102.8 | 99.8 | 102.7 | 104.3 | 92.8 | 77.3 | 109.6 |
| Cavitation | 121.3 | 135.3 | 145.6 | 152.7 | 157.2 | 156.7 | 154.6 | 147.3 | 161.9 |
| Compressor booster | 97.5 | 100.4 | 110.3 | 111.7 | 113.6 | 110.9 | 105.7 | 102.8 | 118.3 |
| Compressors | 100.5 | 101.5 | 108.6 | 109.9 | 109.7 | 107.1 | 100.3 | 91.3 | 115.5 |
| Loading tubing | 103.0 | 98.9 | 101.9 | 98.7 | 106.2 | 106.9 | 103.0 | 94.6 | 112.1 |
| Make up string | 101.7 | 97.2 | 98.9 | 105.4 | 108.8 | 107.3 | 100.5 | 91.6 | 113.1 |
| Pressure testing | 96.0 | 94.6 | 93.1 | 95.0 | 101.5 | 99.9 | 92.6 | 84.4 | 105.8 |

| Well Construction Activity | Octave Sound Power Data - dBA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** | **Overall - dBA** |
| Pull out of hole | 93.7 | 95.6 | 92.2 | 101.0 | 106.9 | 103.9 | 97.1 | 92.0 | 110.0 |
| Rig drive full load | 86.4 | 94.2 | 102.0 | 106.6 | 111.8 | 109.6 | 103.3 | 98.4 | 115.3 |
| Rig drive idle | 86.3 | 91.3 | 97.8 | 102.9 | 108.8 | 106.4 | 99.5 | 92.8 | 112.0 |
| Rig pull down | 100.0 | 94.4 | 94.3 | 97.7 | 110.5 | 105.1 | 94.3 | 82.4 | 112.3 |
| Well unloading | 101.7 | 102.8 | 104.4 | 111.4 | 128.9 | 129.9 | 126.0 | 114.4 | 133.4 |

**Table 26: Operational plant source noise data** (Part A: 20Hz to 500Hz)

| Plant Item | Weight | Parameter | 20 | 25 | 32 | 40 | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Harsco Model 132F end Inlet | A | PWL | 47 | 67 | 72 | 58 | 70 | 75 | 75 | 81 | 83 | 84 | 85 | 86 | 89 | 89 | 88 |
| Harsco Model 132F4 top inlets combined | A | PWL | 53 | 73 | 78 | 64 | 76 | 81 | 82 | 87 | 89 | 90 | 91 | 92 | 95 | 95 | 95 |
| Harsco Model 132F4 side Inlets (one side) | A | PWL | 51 | 66 | 73 | 63 | 74 | 80 | 82 | 83 | 87 | 89 | 90 | 91 | 93 | 94 | 93 |
| Low noise fan option - Howden 13 SX4 | A | PWL | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 69 | 69 | 69 | 73 | 73 | 73 | 77 | 77 |
| Caterpillar G3616 muffled engine exhaust (1 of 2) | A | PWL | 0 | 49 | 49 | 49 | 59 | 59 | 59 | 68 | 68 | 68 | 71 | 71 | 71 | 73 | 73 |
| Spring Gully reverberant level inside GPF | A | SPL | 29 | 44 | 52 | 49 | 60 | 66 | 69 | 71 | 76 | 79 | 83 | 83 | 86 | 87 | 86 |
| Spring Gully flare - 12 TJ | A | PWL | 63 | 63 | 71 | 71 | 74 | 77 | 80 | 87 | 86 | 84 | 88 | 99 | 106 | 103 | 97 |
| 100 kW water transfer pump | A | PWL | 28 | 35 | 26 | 37 | 47 | 49 | 50 | 54 | 62 | 62 | 67 | 73 | 76 | 78 | 78 |
| RO plant generator engines (2 off) | A | PWL | 53 | 73 | 57 | 61 | 67 | 76 | 74 | 76 | 80 | 80 | 86 | 81 | 81 | 82 | 85 |
| RO plant building reverberant level | A | SPL | 23 | 25 | 20 | 29 | 34 | 27 | 34 | 40 | 42 | 48 | 55 | 62 | 64 | 66 | 70 |
| GA18FF ATLAS Copco air compressor | A | PWL | 18 | 35 | 27 | 34 | 45 | 49 | 52 | 57 | 59 | 69 | 70 | 72 | 80 | 79 | 84 |
| 2 x Capstone 30kW microturbine | A | PWL | 31 | 34 | 36 | 41 | 47 | 52 | 60 | 58 | 60 | 65 | 68 | 70 | 74 | 81 | 88 |
| CMG electric well-head | A | PWL | 18 | 21 | 26 | 33 | 37 | 41 | 53 | 50 | 50 | 53 | 57 | 62 | 64 | 62 | 68 |
| Kudu Hydrapack | A | PWL | 35 | 45 | 46 | 55 | 74 | 65 | 70 | 75 | 77 | 74 | 69 | 72 | 73 | 81 | 83 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oil-lift Hydrapack (old type) | A | PWL | 37 | 42 | 46 | 56 | 64 | 71 | 89 | 76 | 78 | 82 | 81 | 86 | 79 | 83 | 86 |
| Oil-lift Hydrapack (new type) | A | PWL | 29 | 43 | 45 | 55 | 61 | 63 | 74 | 84 | 73 | 75 | 76 | 79 | 76 | 81 | 84 |
| Rockwood booster station | A | PWL | 51 | 63 | 73 | 90 | 81 | 88 | 91 | 96 | 99 | 94 | 93 | 98 | 98 | 101 | 101 |
| Spring Gully gas plant total power | A | PWL | 64 | 82 | 88 | 77 | 88 | 93 | 95 | 98 | 101 | 104 | 106 | 107 | 110 | 110 | 109 |
| | | | | | | | | | | | | | | | | | |
| 75TJpd based on scaled Spring Gully + Rockwood | A | PWL | 64 | 82 | 87 | 95 | 90 | 96 | 98 | 103 | 106 | 104 | 106 | 108 | 110 | 111 | 110 |
| 150TJpd based on scaled Spring Gully + Rockwood | A | PWL | 67 | 84 | 90 | 98 | 92 | 98 | 101 | 106 | 108 | 107 | 109 | 110 | 112 | 113 | 113 |
| 225TJpd based on scaled Spring Gully + Rockwood | A | PWL | 68 | 86 | 92 | 100 | 94 | 100 | 103 | 108 | 110 | 108 | 110 | 112 | 114 | 115 | 115 |
| | | | | | | | | | | | | | | | | | |
| Spring Gully total (enclosed compression trains) | A | PWL | 64 | 82 | 88 | 76 | 87 | 92 | 94 | 97 | 100 | 101 | 103 | 104 | 106 | 107 | 106 |
| 75TJpd with enclosed compression trains | A | PWL | 65 | 83 | 89 | 77 | 88 | 93 | 95 | 98 | 101 | 102 | 104 | 105 | 107 | 108 | 107 |
| 150TJpd with enclosed compression trains | A | PWL | 68 | 86 | 92 | 80 | 91 | 96 | 98 | 101 | 104 | 105 | 107 | 108 | 110 | 111 | 110 |
| 225TJpd with enclosed compression trains | A | PWL | 70 | 88 | 94 | 82 | 92 | 98 | 100 | 103 | 105 | 107 | 109 | 109 | 112 | 112 | 112 |

**Table 27: Operational plant source noise data** (Part B: 630Hz to 10kHz, plus overall level)

| Plant Item | Weight | Parameter | 630 | 800 | 1000 | 1250 | 1600 | 2000 | 2500 | 3150 | 4000 | 5000 | 6300 | 8000 | 10000 | SUM(A) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Harsco Model 132F end inlet | A | PWL | 88 | 87 | 88 | 88 | 88 | 88 | 87 | 87 | 85 | 85 | 84 | 81 | 74 | 100 |
| Harsco Model 132F4 top inlets combined | A | PWL | 94 | 94 | 94 | 94 | 94 | 94 | 93 | 93 | 92 | 91 | 90 | 87 | 80 | 106 |
| Harsco Model 132F4 side Inlets (one side) | A | PWL | 93 | 92 | 92 | 93 | 93 | 91 | 91 | 93 | 95 | 89 | 87 | 80 | 72 | 105 |
| Low noise fan option - Howden 13 SX4 | A | PWL | 77 | 78 | 78 | 78 | 74 | 74 | 74 | 67 | 67 | 67 | 55 | 55 | 55 | 87.1 |
| Caterpillar G3616 muffled engine exhaust (1 of 2) | A | PWL | 73 | 85 | 85 | 85 | 84 | 84 | 84 | 83 | 83 | 83 | 88 | 88 | 88 | 96 |
| Spring Gully reverberant level inside GPF | A | SPL | 87 | 88 | 88 | 89 | 92 | 89 | 90 | 93 | 93 | 89 | 85 | 83 | 74 | 101 |
| Spring Gully flare - 12 TJ | A | PWL | 104 | 106 | 102 | 106 | 110 | 106 | 106 | 103 | 98 | 94 | 80 | 75 | 62 | 116 |
| 100 kW water transfer pump | A | PWL | 80 | 83 | 86 | 85 | 80 | 80 | 82 | 79 | 83 | 79 | 74 | 72 | 68 | 93 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RO plant generator engines (2 off) | A | PWL | 85 | 85 | 88 | 89 | 88 | 87 | 87 | 84 | 82 | 78 | 73 | 68 | 62 | 98 |
| RO plant building reverberant level | A | SPL | 72 | 71 | 73 | 74 | 77 | 78 | 76 | 75 | 76 | 69 | 66 | 69 | 60 | 85 |
| GA18FF ATLAS Copco air compressor | A | PWL | 83 | 89 | 83 | 82 | 80 | 77 | 82 | 77 | 73 | 71 | 67 | 63 | 60 | 93 |
| 2 x Capstone 30kW microturbine | A | PWL | 83 | 78 | 81 | 83 | 77 | 84 | 82 | 83 | 82 | 85 | 82 | 75 | 73 | 94 |
| CMG electric well-head | A | PWL | 72 | 76 | 80 | 74 | 79 | 82 | 78 | 83 | 81 | 78 | 78 | 69 | 62 | 90 |
| Kudu Hydrapack | A | PWL | 81 | 85 | 83 | 84 | 84 | 83 | 81 | 80 | 77 | 74 | 72 | 68 | 64 | 93 |
| Oil-lift Hydrapack (old type) | A | PWL | 89 | 91 | 92 | 89 | 91 | 90 | 89 | 86 | 85 | 82 | 79 | 74 | 70 | 100 |
| Oil-lift Hydrapack (new type) | A | PWL | 75 | 77 | 76 | 74 | 73 | 75 | 73 | 70 | 67 | 65 | 63 | 60 | 58 | 90 |
| Rockwood booster station | A | PWL | 101 | 102 | 102 | 104 | 103 | 105 | 103 | 101 | 98 | 95 | 94 | 105 | 83 | 114 |
| Spring Gully gas plant total power | A | PWL | 110 | 110 | 110 | 111 | 113 | 111 | 111 | 115 | 114 | 110 | 107 | 106 | 100 | 123 |
| 75TJpd based on scaled Spring Gully + Rockwood | A | PWL | 111 | 112 | 112 | 113 | 114 | 113 | 112 | 114 | 114 | 110 | 107 | 112 | 99 | 124 |
| 150TJpd based on scaled Spring Gully + Rockwood | A | PWL | 113 | 114 | 114 | 116 | 116 | 116 | 115 | 117 | 116 | 112 | 110 | 114 | 102 | 127 |
| 225TJpd based on scaled Spring Gully + Rockwood | A | PWL | 115 | 116 | 116 | 117 | 118 | 117 | 117 | 119 | 118 | 114 | 111 | 116 | 103 | 128 |
| Spring Gully total (enclosed compression trains) | A | PWL | 106 | 105 | 105 | 106 | 106 | 105 | 104 | 105 | 106 | 102 | 102 | 100 | 99 | 118 |
| 75TJpd with enclosed compression trains | A | PWL | 107 | 106 | 106 | 107 | 107 | 106 | 105 | 106 | 107 | 103 | 103 | 101 | 99 | 119 |
| 150TJpd with enclosed compression trains | A | PWL | 110 | 109 | 109 | 110 | 110 | 109 | 108 | 109 | 110 | 106 | 106 | 104 | 102 | 122 |
| 225TJpd with enclosed compression trains | A | PWL | 111 | 111 | 111 | 111 | 112 | 111 | 110 | 111 | 112 | 108 | 108 | 106 | 104 | 123 |

## Table 28: Enclosure transmission loss data

| Item | Transmission loss data - dB | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| Enerflex EFX-100 panel | 14 (estimate) | 18 | 22 | 26 | 36 | 44 | 46 | 50 | 47 |

| Item | Transmission loss data - dB | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 31 | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |

# Appendix E – Noise contour maps

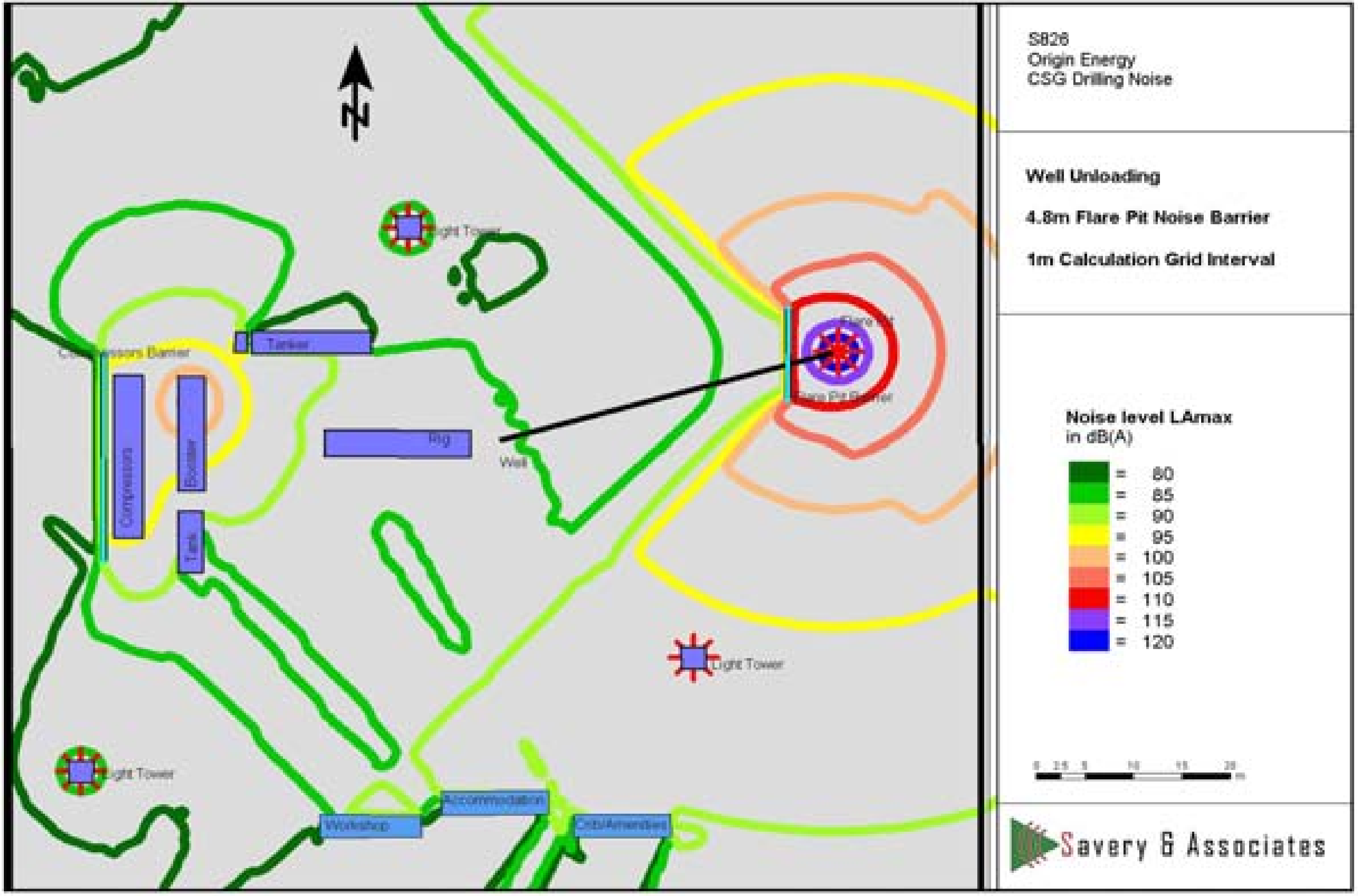



Figure 30: Gas well unloading – lease area map with 4.8m flare-pit noise barrier

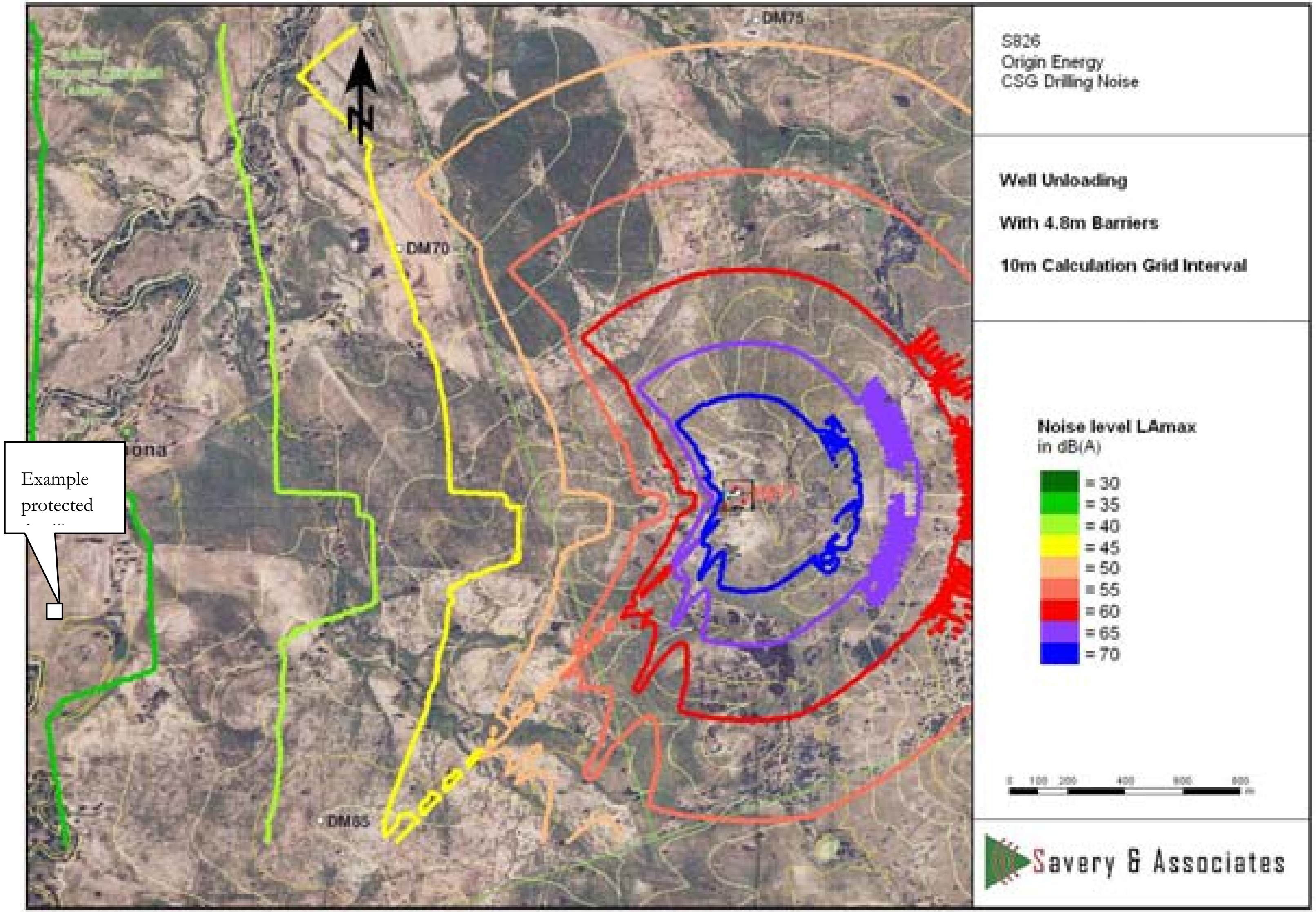



Figure 31: Gas well unloading with noise barrier

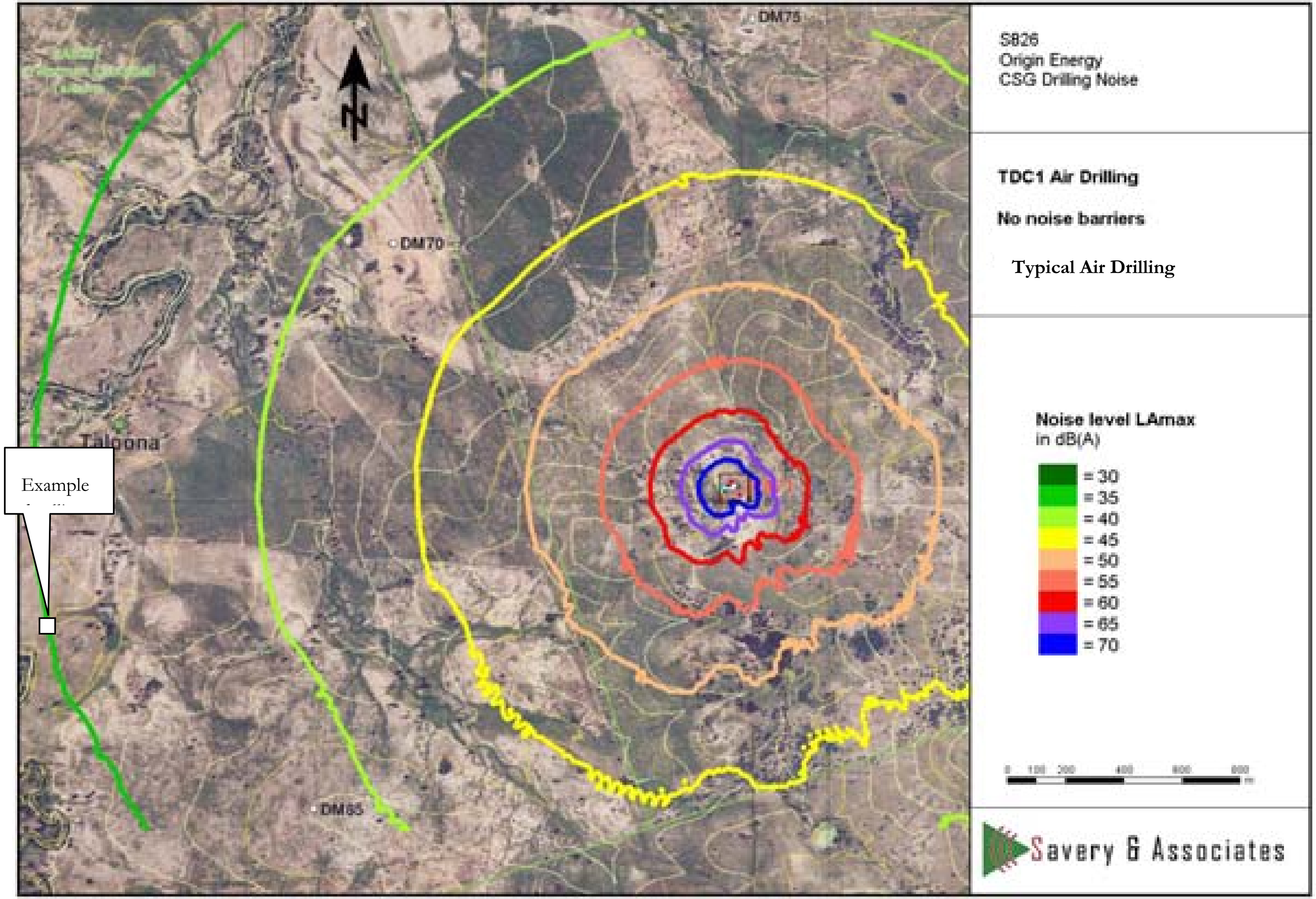



Figure 32: Typical noise map for air-drilling with existing technologies

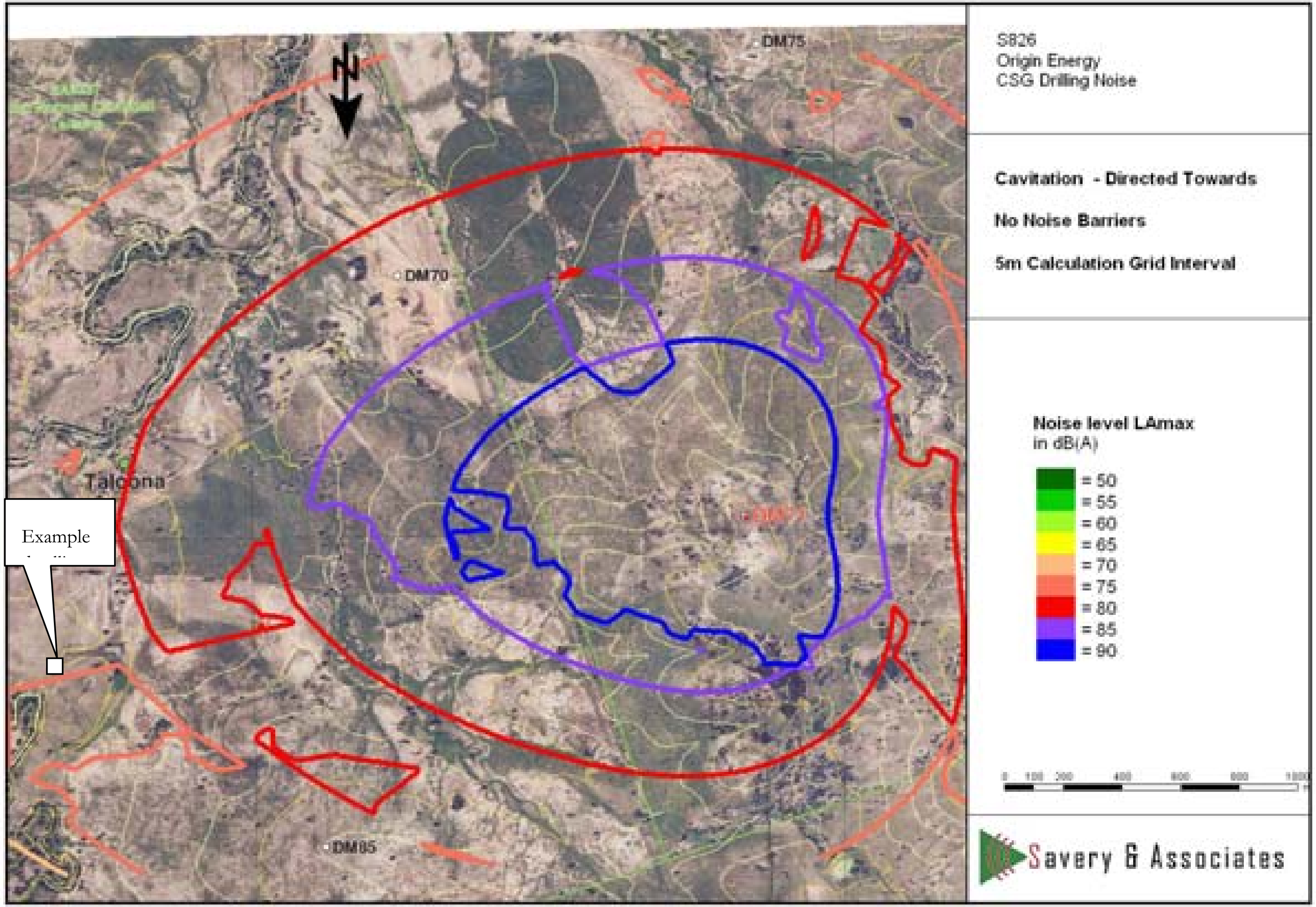



**Figure 33: Modelled cavitation noise with flare-line directed towards dwelling**

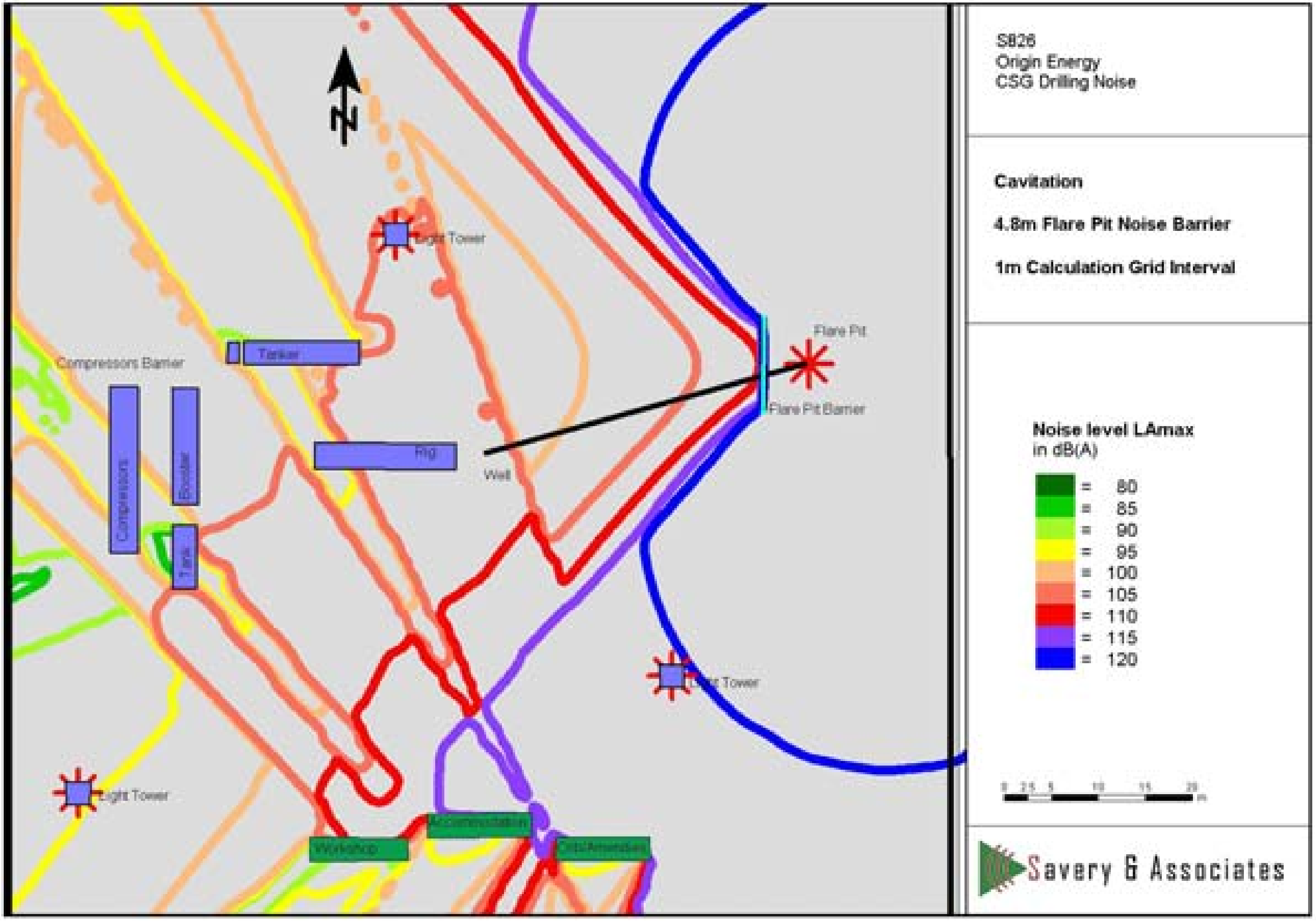



Figure 34: Cavitation noise with noise barrier 5m from end of flare line

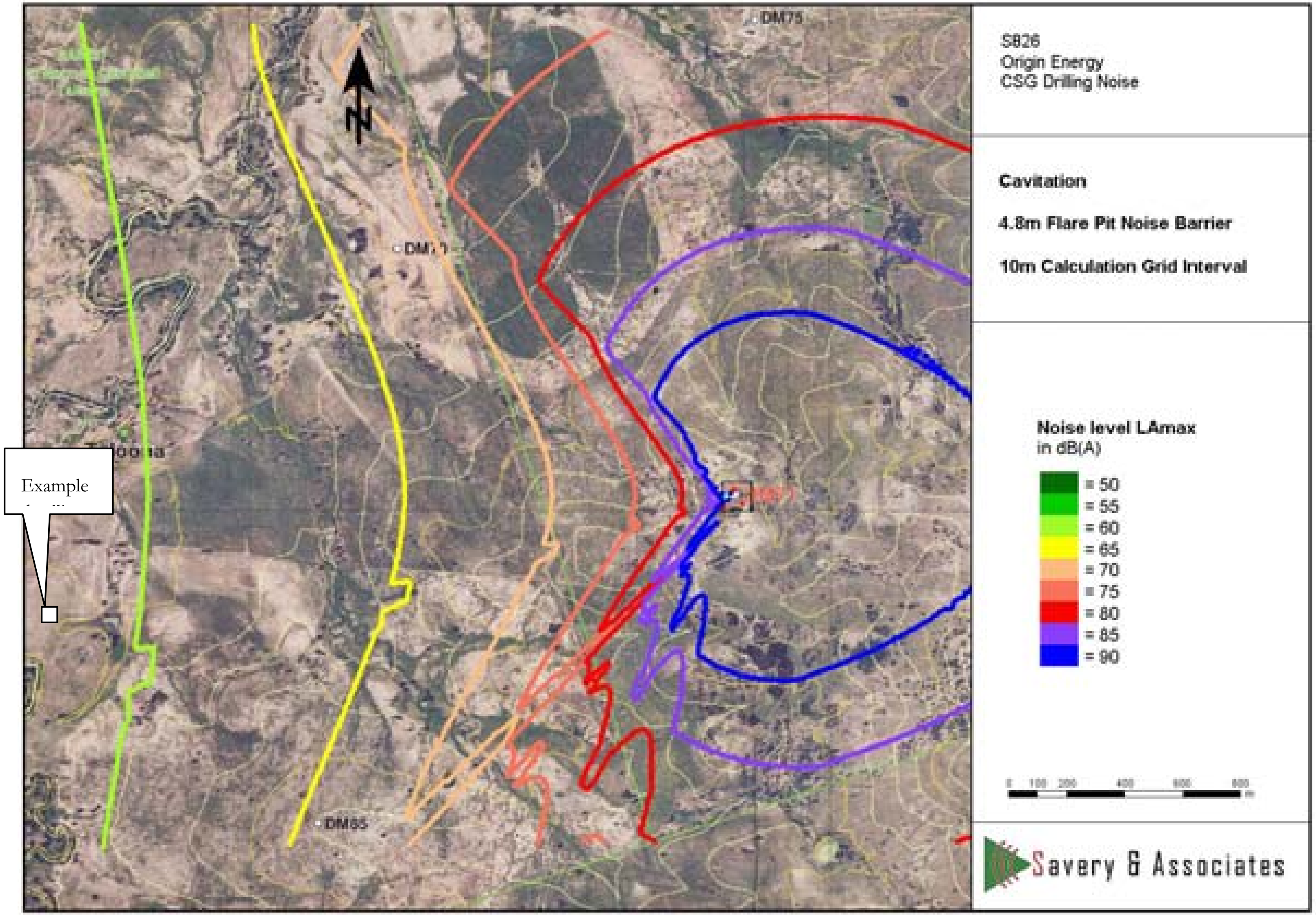



Figure 35: Cavitation noise with flare line directed away from dwelling plus flare-line noise barrier

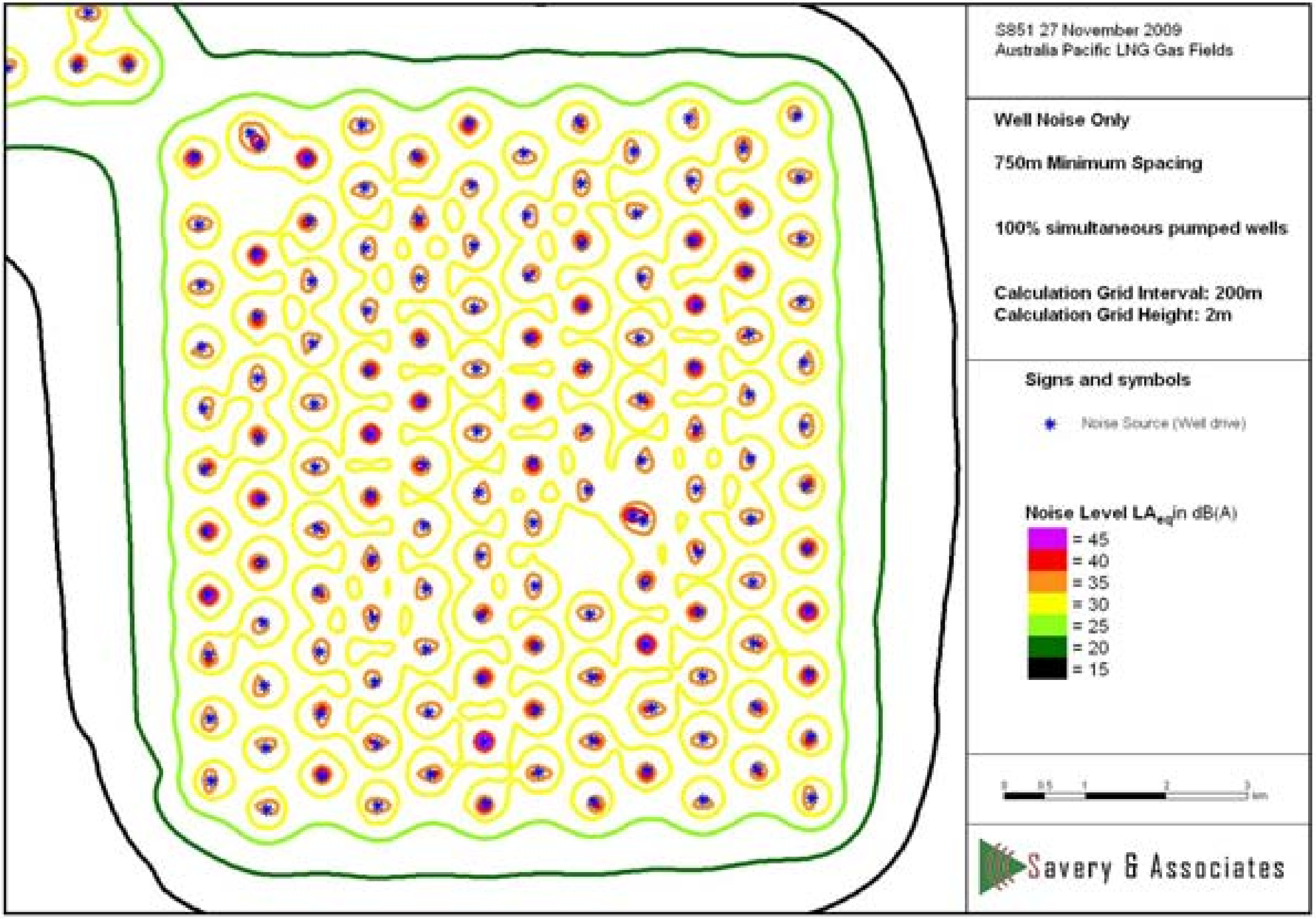



Figure 36: Noise contours for array of well-head drives

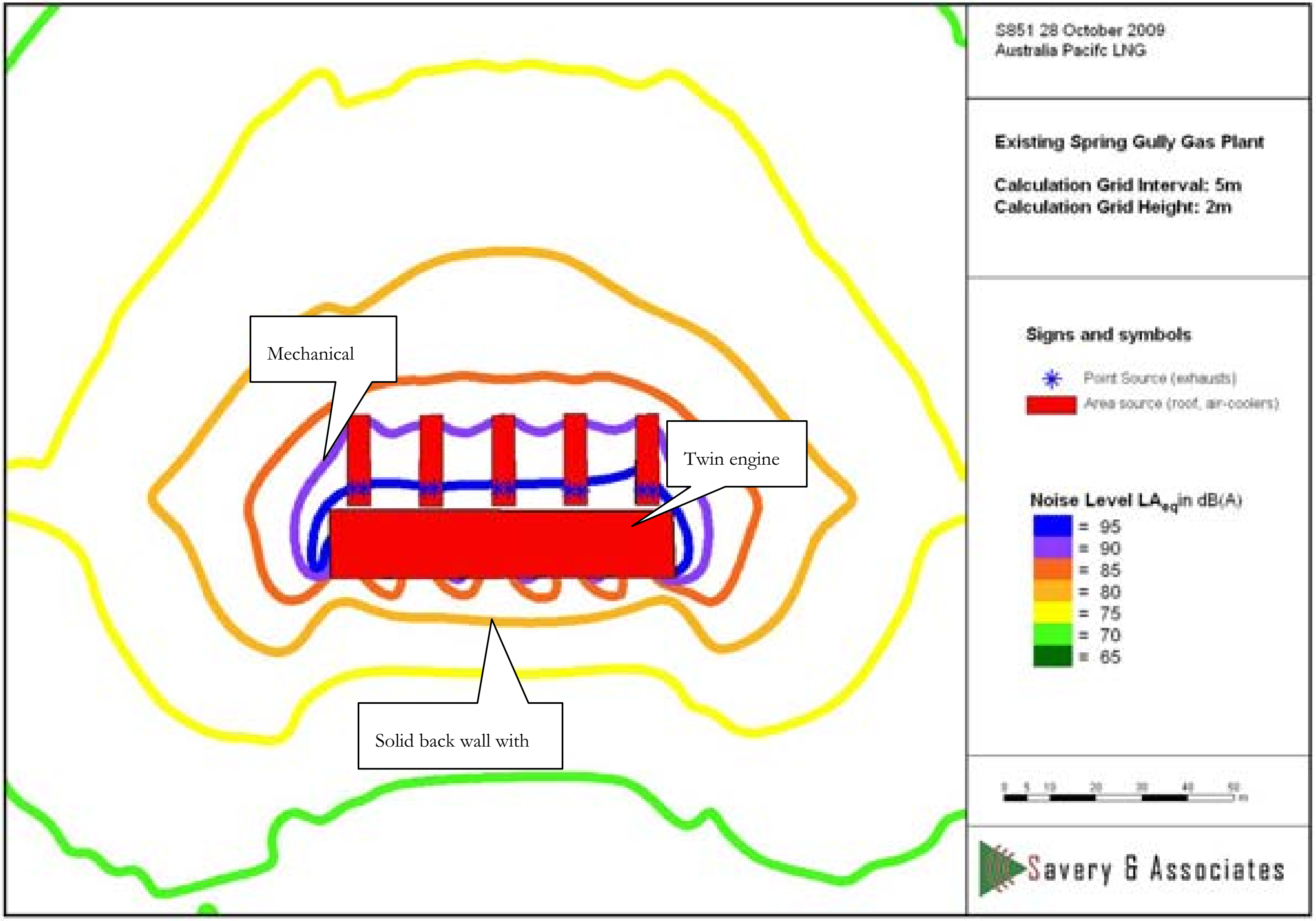



Figure 37: Noise contours near to 60TJpd GPF

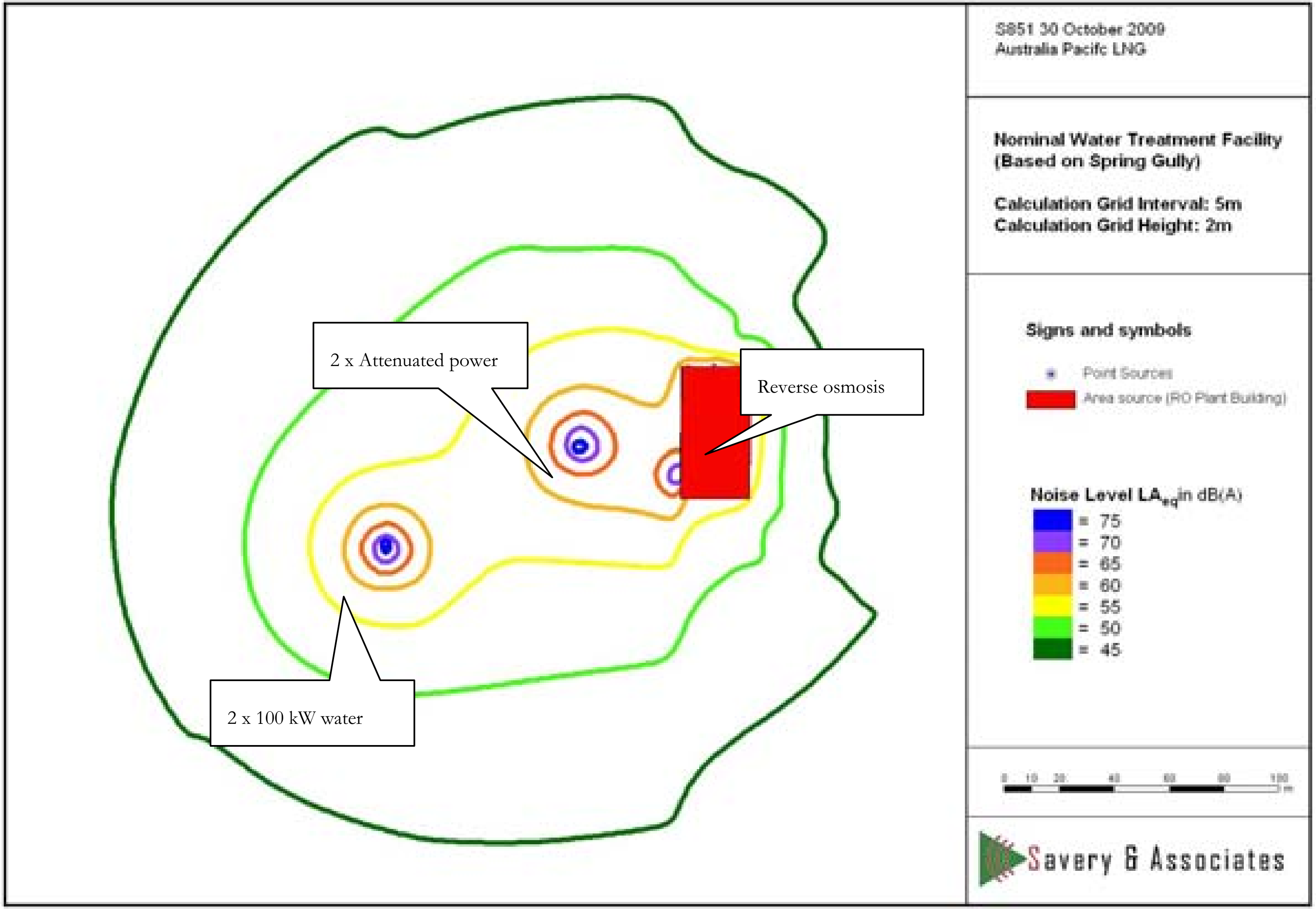



**Figure 38: Flat-terrain noise contours for nominal water treatment facility**