Noise and vibration

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Enter ▶ Go back to contents ▶

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Gas Field Development Project

Environmental Impact Statement

Noise and Vibration Impact Assessment

Report Number 620.10745-R2

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Santos GLNG Project
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Brisbane
QLD 4000

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Gas Field Development Project

Environmental Impact Statement

Noise and Vibration Impact Assessment

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
Suite 7, 240 Waterworks Road Ashgrove QLD 4060 Australia

(PO Box 844 Ashgrove QLD 4060 Australia)
T: 61 7 3858 4800 F: 61 7 3858 4801
E: brisbane@slrconsulting.com www.slrconsulting.com

Table of Contents

Table of Contents

Table of Contents

TABLES

FIGURES

Table of Contents

APPENDICES

EXECUTIVE SUMMARY

Introduction

Santos GLNG intends to further develop its Queensland gas resources to augment supply of natural gas to its existing and previously approved Gladstone Liquefied Natural Gas (GLNG) Project.

The Santos GLNG Gas Field Development Project (the GFD Project) is an extension of the existing approved gas field development and will involve the construction, operation, decommissioning and rehabilitation of production wells and the associated supporting infrastructure needed to provide additional gas over a project life exceeding 30 years.

SLR Consulting Pty Ltd (SLR) has been engaged by URS Australia, on behalf of Santos GLNG, to conduct an assessment of the potential noise and vibration impacts associated with the GFD Project. Noise and vibration emissions have been assessed with reference to section 4.9 of the Terms of reference (ToR) for the GFD Project environmental impact statement (EIS).

The purpose of this report is to assess the potential noise impacts for the GFD Project (based on various construction and operational development scenarios) and then, based on this assessment, detail management measures for the GFD Project to avoid, minimise and mitigate the potential impacts and comply with the requirements of the ToR.

Existing Environment

The monitored background noise levels, establishing during the GLNG Project EIS (2009 EIS) and Australia Pacific Liquefied Natural Gas (APLNG) EIS (2010), follow typical diurnal pattern with noise levels reduced during the evening and night-time periods when bird, insect and road traffic activity is negligible.

Measured A-weighted noise levels of below 30 dBA exceeded for 90% of the measurement period (L_{A90}) during the daytime and below 20 dBA L_{A90} during the evening and night-time are low and characteristic of rural environments with minimal noise influences.

Measurements of background noise levels for the 2009 and APLNG EIS were both conducted during the cooler winter months. The ambient acoustic environment is likely to more often contain additional insect noise during the warmer months of the year. The potential for noise impacts is greater during the winter months when background noise levels are lower at night. On this basis, the measured background noise levels would represent the worst case in terms of seasonal variations.

Based on the existing noise environment with typically very low background noise levels, the nearest sensitive receptors and communities to the GFD Project may be sensitive to the level and characteristic of audible noise from the GFD Project.

Project Criteria

In February 2012, the Queensland Department of Environment and Heritage Protection (EHP), formerly Department of Environment and Resource Management (DERM), published the guideline *Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities* (Noise Assessment Guideline) to supplement the application of the *Environmental Protection (Noise) Policy 2008* (EPP Noise) in the administration of an environmental authority (EA) for petroleum and gas activity projects.

This guideline applies to the GFD Project as it specifies 'best practice' noise limits (refer to **Table E1**), which are considered to protect the acoustic values of a sensitive receptor in rural or isolated areas and achieve acoustic quality objectives set out in the EPP Noise, whilst considering cumulative impacts and background creep.

Table E1 Best practice noise limits

Time period	Parameter	Noise limit (dBA)		
		Short-term[1]	Medium-term[2]	Long-term[3]
7:00 am – 6:00 pm	$L_{Aeq, adj, 15mins}$	45	43	40
6:00 pm – 10:00 pm	$L_{Aeq, adj, 15mins}$	40	38	35
10:00 pm – 6:00 am	$L_{Aeq, adj, 15mins}$	28	28	28
	Max $L_{pA, 15 mins}$	55	55	55
6:00 am – 7:00 am	$L_{Aeq, adj, 15mins}$	40	38	35

Note 1: A short-term noise event is defined as a noise exposure lasting for no greater than eight hours and does not reoccur for at least seven (7) days.

Note 2: A medium-term noise event is defined as a noise exposure lasting for no greater than five days and does not reoccur for at least four (4) weeks.

Note 3: A long-term noise event is defined as a noise exposure lasting for greater than five days, even when there are respite periods when noise is inaudible within those five days. Most construction and operations scenarios will fall within this long-term noise event specification.

For further details of applicable criteria see **Section 5.1**.

Noise and vibration impact assessment

The noise and vibration impact assessment has predicted noise and vibration emission levels for several construction and operational scenarios.

The distances to various noise levels have been predicted and are presented in **Table E2** and **Table E3** for construction and operation scenarios respectively.

Table E2 and **Table E3** show the potential impact distances for each construction and operational scenario where the relevant noise criteria may be exceeded. Grey highlighted cells therefore represent the distances where further noise management and mitigation measures may be required. Further noise management and mitigation measures are discussed in **Section 7** of this report. Remaining cells show the predicted distances outside which the activities are likely to achieve the relevant criteria without further noise management and mitigation measures for each modelled scenario.

Table E2 Potential impact distances for various predicted noise levels – construction

Construction scenario	Weather condition	Impact distance to predicted noise level (m)[2]								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Drilling and completion[1]	Neutral	200 (300)	350 (600)	450 (850)	650 (1,200)	900 (1,600)	1,300 (2,200)	1,800 (2,900)	2,000 (3,200)	2,400 (3,800
Drilling and completion[1]	Adverse	250 (450)	500 (900)	700 (1,200)	950 (1,700)	1,300 (2,300)	1,800 (3,100)	2,500 (4,000)	2,800 (4,400)	3,300 (5,100)
Gas compression facilities	Neutral	150	300	450	650	1,000	1,500	2,100	2,400	2,900
Gathering/transmissi on lines	Neutral	150	250	350	550	800	1,200	1,800	2,000	2,500
Borrow pits	Neutral	150	350	500	800	1,200	1,700	2,400	2,700	3,200
Laydown areas	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Communication infrastructure	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Road/access tracks	Neutral	100	150	250	350	550	850	1,300	1,500	1,900

Note 1: Values in brackets includes operation of blooie line.

Note 2: Noise limit of 40 dBA assumed for day time activities; 28 dBA assumed for 24-hour activities.

Table E3 Potential impact distances for various predicted noise levels – operation

Operation scenario	Weather condition	Impact distance to predicted noise level (m) [1]								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Hub gas compression facility (non-electrified)	Neutral	300	600	900	1,300	1,900	2,700	3,700	4,100	4,900
Hub gas compression facility (electrified)		160	350	550	800	1,200	1,700	2,500	2,800	3,400
Nodal gas compression facility		150	350	500	750	1,100	1,600	2,200	2,500	3,000
Water treatment facility		<50	70	110	160	250	350	550	650	800
Well (non-electrified)		<50	50	60	80	140	200	300	350	450
Well (electrified/ free-flowing)		<50	<50	<50	<50	<50	60	80	100	130
Gas compression facility - flaring		200	500	700	1,100	1,500	2,200	2,900	3,300	3,800
Accommodation camp		<50	140	200	300	500	700	1,000	1,200	1,500
Hub gas compression facility (non-electrified)	Adverse	400	900	1,300	1,900	2,700	3,700	4,900	5,500	6,500
Hub gas compression facility (electrified)		200	500	800	1,200	1,800	2,600	3,600	4,100	4,800
Nodal gas compression facility		250	500	750	1,200	1,700	2,300	3,200	3,500	4,200
Water treatment facility		<50	80	130	250	350	550	800	950	1,200
Well (non-electrified)		<50	50	60	110	180	300	450	550	700
Well (electrified/ free-flowing)		<50	<50	<50	<50	<50	60	80	110	150
Gas compression facility - flaring		300	700	1,100	1,600	2,200	3,000	3,900	4,400	5,100
Accommodation camp		<50	160	250	400	600	900	1,400	1,600	2,000

Note 1: Noise limit of 28 dBA assumed for 24-hour activities.

The predicted vibration levels showed that the distances required to achieve the vibration criteria were approximately 5 m for building damage and up to 50 m for human annoyance. These are significantly shorter compared to those required to achieve the noise criteria and no impacts are anticipated from vibrations associated with the construction or operation of the GFD Project.

Transportation

There are no predicted noise exceedances associated with GFD Project related vehicle movements on State-controlled roads.

A public road with a speed limit of 80 kilometres per hour (km/h) could carry up to 4,000 light vehicles per day and achieve the $L_{A10(18hour)}$ road traffic noise criterion of 63 dBA at a distance of 25 m from the road edge. If conservatively assuming 50% heavy vehicles, the number of allowed vehicle movements is reduced to 1,000 vehicles per day at 80 km/h. For public roads or access roads with dirt or chip seal road surface, the number of allowed vehicle movements is reduced further to approximately 250 vehicle movements per day at 80 km/h. However, it is noteworthy that on access roads the speed limits is likely to be less than 80 km/h and distance to sensitive receptors likely to be greater than 25 m.

Cumulative impacts

The cumulative noise predictions show that cumulative noise levels may need to be considered if a major GFD Project facility (water treatment, nodal or hub gas compression facility) and another projects major facility are located within approximately 9.8 km and 13 km of each other for neutral and adverse weather conditions respectively. For situations where a GFD Project facility and another facility are located within the predicted cumulative impact distances, more detailed modelling will be conducted to determine if further noise management and mitigation measures as outlined in **Section 7** are required.

The cumulative noise assessment of multiple well leases predicts no cumulative noise build-up within the high density gas fields (600 m between wells) with electrified or free flowing wells. A marginal cumulative noise build-up was shown for the non-electrified wells in the low density well configuration (1,000 m between wells). Effective placement of wells (in accordance with the Constraints protocol) will help mitigate potential impacts on sensitive receptors.

Management and Mitigation Measures

A summary of the GFD Project's commitments to manage and minimise potential noise impacts is listed in **Table E8**. **Section 7** of this report give further details of the procedures outlined within the existing Santos GLNG management systems and plans as they relate to noise management.

Table E8 Management plans and mitigation measures

Management plan	Commitment
GFD Project Environmental protocol for constraints planning and field development (the Constraints protocol)	The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to: • Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation • Support Santos GLNG's environmental policies and the General Environmental Duty (GED) as outlined in the Environmental Protection Act 1994 (Qld) (EP Act) • Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances • Minimise cumulative impacts on environmental values. The Constraints protocol provides a framework to guide placement of infrastructure and adopts the following management principles: • Avoidance — avoiding direct and indirect impacts • Minimisation — minimise potential impacts • Mitigation — implement mitigation and management measures • Remediation and rehabilitation — actively remediate and rehabilitate impacted areas • Off-set — offset residual adverse impacts in accordance with regulatory requirements.

Management plan	Commitment
	The Constraints protocol enables the systematic identification and assessment of environmental values and the application of development constraints to effectively avoid and / or manage environmental impacts. Noise is identified as a planning constraint within the Constraints protocol. Noise constraints will be identified and managed in accordance with the noise management plan.
Noise management plan (NMP)	The NMP identifies potential noise impacts from Santos GLNG activities and provides a strategy, methods and controls to: • Avoid — plan the activity and engage with potentially affected stakeholders • Minimise — implement noise mitigation measures to minimise noise impacts • Manage — conduct monitoring, review mitigation methods and ensure compliance with Santos GLNG procedures. Noise will be managed in accordance with the NMP, which details: • Risk / constraint analysis methods to be undertaken prior to new operation or installation of new equipment that has the potential to create noise nuisance • Procedures and methods to undertake noise assessments to determine compliance with the stipulated noise limits • Procedures for handling noise complaints, and procedures for community liaison and consultation • Details of petroleum activities and measured and / or predicted noise levels of noise sources associated with those activities • Reasonable and practicable control or abatement measures to ensure compliance with the established noise limits • Mediation processes to be used in the event that noise complaints are not able to be resolved.
Draft EM Plan	The Draft EM Plan provides the environmental monitoring and assessment approach Santos GLNG implements across its development activities.

Conclusion

The noise and vibration impact assessment has predicted noise emission levels at various distances from the assessed construction and operational scenarios. Depending on the future locations of major facilities and infrastructure associated with the GFD Project, further management and mitigation measures may be required if sensitive receptors are identified within the determined impact distances in **Table E2** for construction and **Table E3** for operations.

If sensitive receptors are identified within the specified impact distances, more detailed modelling would be performed to enable locality-specific factors, such as the surrounding topography and land use, to be accounted for in the modelling and investigate if further noise management and/or mitigation measures are required. Noise management and mitigation measures that should be considered are outlined in **Section 7**.

There are no anticipated impacts associated with the construction or operation of the GFD Project.

ABBREVIATIONS

%	percent
°C	degrees Celsius
AADT	Annual average daily traffic
APLNG	Australian Pacific LNG
AS	Australian Standard
DGA	Dense Graded Asphalt
DERM	Queensland Department of Environment and Resource Management (now EHP)
TMR	Queensland Department of Transport and Main Roads
TMR Code of Practice	TMR Road Traffic Noise Management: Code of Practice
EA	Environmental Authority
EHP	Queensland Department of Environment and Heritage Protection (formerly DERM)
EHS	Environment Hazard Standard
EIS	Environmental Impact Statement
EPA	Queensland Environmental Protection Agency (now EHP)
EP Act	*Environmental Protection Act 1994* (Qld)
EP Regulation	*Environmental Protection Regulation 2008* (Qld)
EPP Noise	*Environmental Protection (Noise) Policy 2008* (Qld)
FEL	front-end loader
GFD Project	Gas Field Development Project
GLNG Project	Gladstone Liquid Natural Gas Project
Hz	Hertz (unit of measurement for frequency)
IAS	Initial Advice Statement
km	kilometre
km^2	square kilometre
m	metre
M	million
m/s	metre per second
m^2	square metre
min	minute
mm	millimetre
NMP	Noise Management Plan
MW	megawatt
RBL	Rating Background Level
SLR	SLR Consulting Australia Pty Ltd
SWL	Sound Power Level
t	tonne
TEG	Triethylene glycol (TEG) dehydrator packages
TJ	terajoule: 1.0×10^{12} J
ToR	Terms of Reference
URS	URS Australia Pty Ltd
UTM	Universal Transverse Mercator
WHO	World Health Organisation

GLOSSARY

Background noise	The existing noise level in the Project area excluding the impacts from the Project
CoRTN	Calculation of Road Traffic Noise
CONCAWE	'The propagation of noise from petroleum and petrochemical complexes to neighbouring communities' prediction method
dBA	Decibels, A-weighted
dBZ	Decibels, unweighted or linear
GFD Project facility	Includes water treatment and nodal and hub gas compression facilities.
Guideline	A general rule, principle, or piece of advice. A statement or other indication of policy or procedure by which to determine a course of action.
LA90	Noise level (in decibels – A weighted) exceeded for 90 percent of the measurement period
LAeq	Equivalent continuous (or 'average') noise level (in decibels – A weighted) over a measurement period
LA10	Noise level (in decibels – A weighted) exceeded for 10 percent of the measurement period
LAmax	Maximum noise level
Long term noise	A noise exposure lasting for greater than five (5) days, even when there are respite periods when noise is inaudible within those five (5) days.
Medium term noise	A noise exposure lasting not greater than five (5) days and does not re-occur for a period of at least four (4) weeks. Re-occurrence is deemed when a noise exposure of comparable level occurs for a period of one hour or more, even if it originates from a difference source or location.
Meteorological	The science that deals with the phenomena of the atmosphere, especially weather and weather conditions
Qualitative assessment	An assessment of impacts based on a subjective, non-statistical oriented analysis
Quantitative assessment	An assessment of impacts based on estimates of emission rates and air dispersion modelling techniques to provide estimate values of ground level pollutant concentrations.
Sensitive receptor	Locations such as residential dwellings, hospitals, churches, schools, recreation areas etc where people (particularly the young and elderly) may often be present
Short term noise	A noise exposure lasting not greater than 8 hours and does not re-occur for a period of at least seven (7) days. Re-occurrence is deemed when a noise exposure of comparable level occurs for a period of one hour or more, even if it originates from a difference source or location.
Standard	The prescribed level of a pollutant in the outside air that should not be exceeded during a specific time period to protect public health
Triethylene glycol (TEG) dehydrator packages	Triethylene glycol (TEG) dehydrator packages including reflux columns and TEG regenerative boilers form unit process of gas compression facility
Topography	Detailed mapping or charting of the features of a relatively small area, district, or locality

1 INTRODUCTION

SLR Consulting Pty Ltd (SLR) has been engaged by URS Australia, on behalf of Santos GLNG, to conduct an assessment of the potential noise and vibration impacts associated with the Santos GLNG Gas Field Development Project (the GFD Project). Noise and vibration emissions have been assessed with reference to the *Terms of reference* (ToR) *for an environmental impact statement* (EIS), issued March 2013.

The purpose of this report is to assess the potential noise impacts for the GFD Project (based on various construction and operational development scenarios) and then, based on this assessment, detail management measures for the GFD Project to avoid, minimise and mitigate the potential impacts and comply with the requirements of the ToR. Specific acoustic terminology is used within this assessment. An explanation of common acoustic terms is included as **Appendix A**.

2 PROJECT DESCRIPTION

Santos GLNG intends to further develop its Queensland gas resources to augment supply of natural gas to its existing and previously approved Gladstone Liquefied Natural Gas (GLNG) Project. The Santos GLNG GFD Project is an extension of the existing approved gas field development and will involve the construction, operation, decommissioning and rehabilitation of production wells and the associated supporting infrastructure needed to provide additional gas over a project life exceeding 30 years.

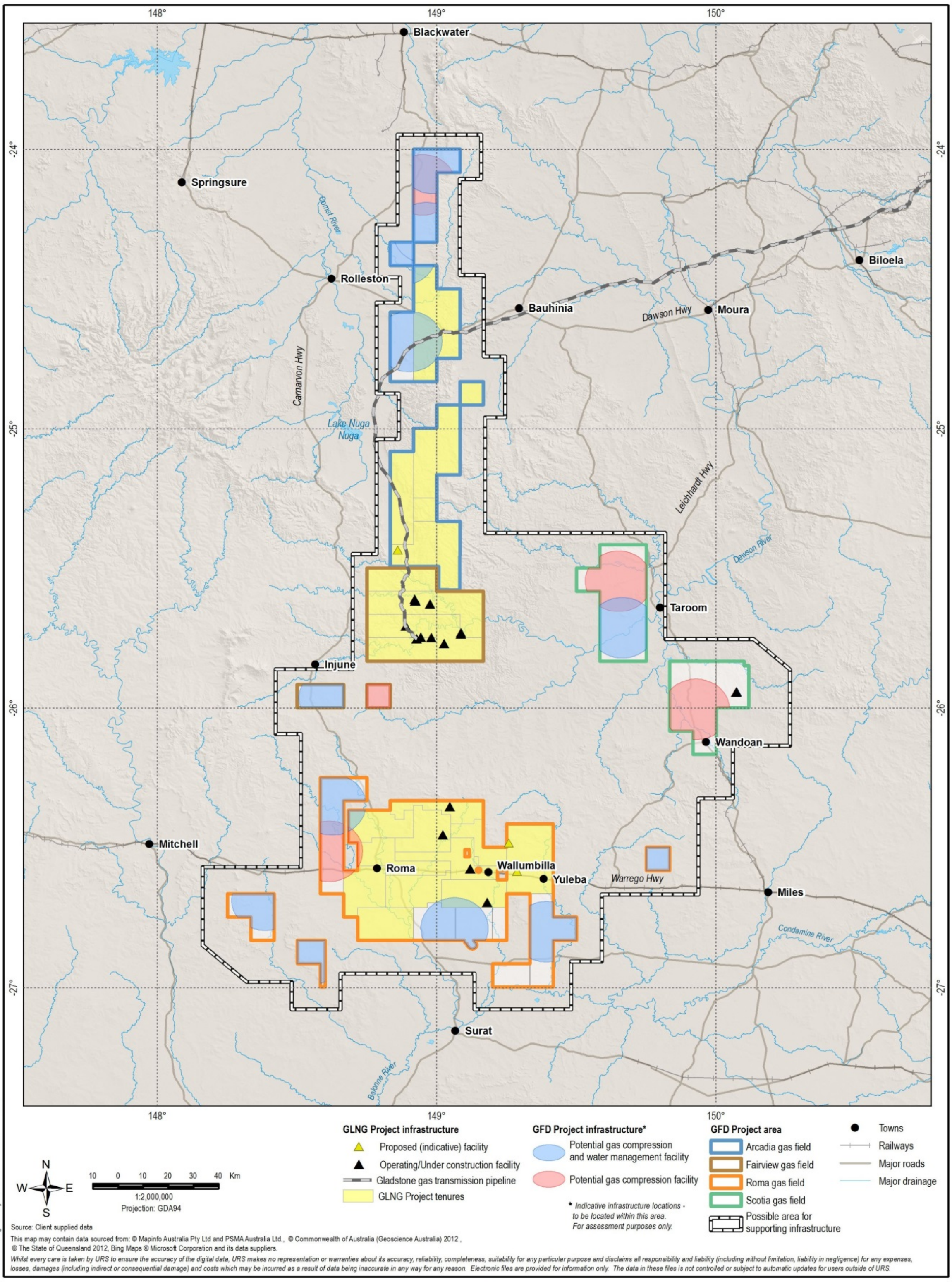
Specifically, the GFD Project seeks approval to expand the GLNG Project's gas fields from 6,887 km^2 to 10,676 km^2 and develop up to 6,100 production wells beyond the currently authorised 2,650 wells; resulting in a maximum of up to 8,750 production wells.

The GFD Project will continue to progressively develop the Arcadia, Fairview, Roma and Scotia gas fields across 35 Santos GLNG petroleum tenures in the Surat and Bowen basins, and associated supporting infrastructure in these tenures and in adjacent areas. The location of the GFD Project area and primary infrastructure is shown on **Figure 1**.

This GFD Project will include the following components:

- Production wells
- Fluid injection wells, monitoring bores and potentially underground gas storage wells
- Gas and water gathering lines
- Gas and water transmission pipelines
- Gas compression and treatment facilities
- Water storage and management facilities
- Access roads and tracks
- Accommodation facilities and associated services (e.g. sewage treatment)
- Maintenance facilities, workshops, construction support, warehousing and administration buildings
- Utilities such as water and power generation and supply (overhead and/or underground)
- Lay down, stockpile and storage areas
- Borrow pits and quarries
- Communications.

Figure 1 GFD Project area and major infrastructure



Source: URS, 2014; File number 42627064-g-1051j.mxd

The final number, size and location of the components will be determined progressively over the GFD Project life and will be influenced by the location, size and quality of the gas resources identified through ongoing field development planning processes, which include consideration of land access agreements negotiated with landholders, and environmental and cultural heritage values.

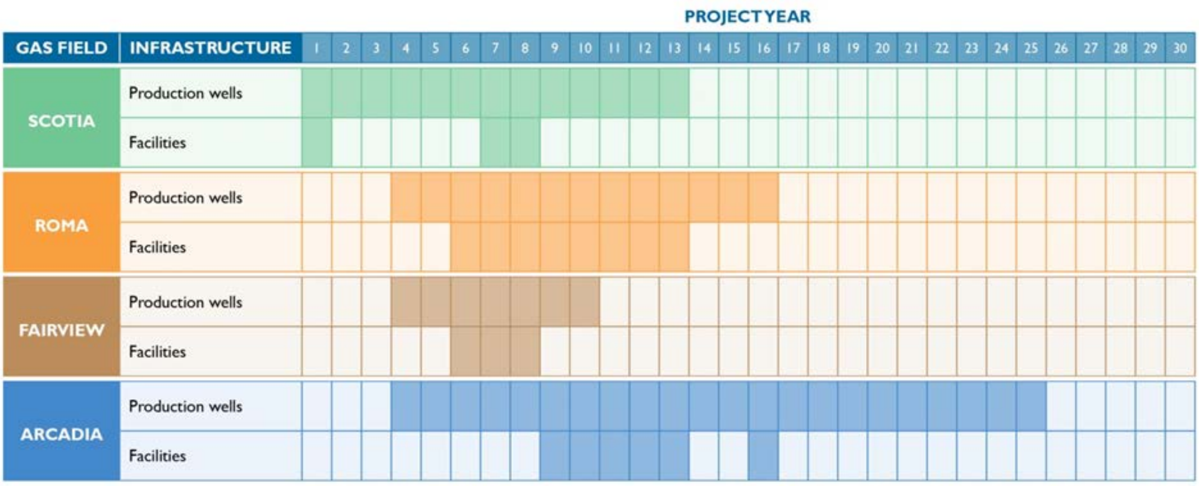
Where practicable, the GFD Project will utilise existing or already approved infrastructure (e.g. accommodation camps, gas compression and water management facilities) from the GLNG Project or other separately approved developments. The GFD Project may also involve sourcing gas from third-party suppliers, as well as the sharing or co-location of gas field and associated facilities with third parties.

For the purposes of transparency this EIS shows an area off-tenure that may be used for infrastructure such as pipelines and temporary camps (supporting infrastructure area). While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

Approved exploration and appraisal activities are currently underway across the GFD Project's petroleum tenures to improve understanding of the available gas resources. As the understanding of gas resources improves, investment decisions will be made about the scale, location and timing of the next stages of field development.

For the purposes of this EIS, a scenario based on the maximum development case was developed at the approval of the ToR. This scenario assumed that production from the wells and upgrading of the gas compression facilities in the Scotia gas field would commence in 2016, followed by the GFD Project wells in the Roma, Arcadia and Fairview gas fields in mid-2019. This schedule is indicative only and was used for the purpose of the impact assessment in this EIS. The proposed GFD Project schedule is outlined in **Figure 2**. This schedule provides an overall field development scenario for the purpose of assessment in this EIS.

Figure 2 Proposed GFD Project development schedule



Decommissioning and rehabilitation will occur progressively throughout the life of the GFD Project as construction activities cease and exhausted gas wells are decommissioned. However, final decommissioning and rehabilitation will occur at the end of gas production in accordance with relevant approvals and regulatory requirements.

3 LEGISLATIVE AND POLICY FRAMEWORK

This section provides an overview of the existing environmental approvals relevant to the GFD Project area and key legislative requirements applicable for the GFD Project in terms of noise and vibration. Relevant criteria and guidelines, and their implications for GFD Project activities are also discussed.

3.1 Relevant legislation, standards and guidelines

Table 1 summarises the relevant legislation and policy context applicable to noise and vibration. Relevant guidelines and standards are listed in **Table 2**.

Table 1 Queensland legislation and policies

Legislation/Policy	Applicability
Environmental Protection Act 1994 (Qld) (EP Act)	The objective of the EP Act is to protect Queensland's environment by promoting ecologically sustainable development. The objective of the EP Act related to management and assessment of noise in Queensland is implemented through the *Environmental Protection Regulation 2008* and *Environmental Protection (Noise) Policy 2008.*
Environmental Protection Regulation 2008 (Qld) (EP Regulation)	The EP Regulation recommends limits to the hours that construction activities can occur.
Environmental Protection (Noise) Policy 2008 (Qld) (EPP Noise)	The EPP Noise is subordinate legalisation developed to achieve the object of the EP Act in relation to the acoustic environment. The EPP Noise: • Identifies environmental values that are to be enhanced or protected • States acoustic quality objectives for enhancing or protecting environmental values • Provides a framework for making consistent, equitable and informed decisions about the acoustic environment.

Table 2 Relevant guidelines and standards

Guideline/Standard	Applicability
Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities (EHP, 2012)	Outlines best practice noise limits for petroleum and gas activities.
Draft Coal Seam Gas Model Conditions for Level 1 Environmental Authority Chapter 5A Petroleum Activity (DERM, 2011)	A template environmental authority for petroleum and gas activities prescribing relevant conditions.
Planning for Noise Control (EPA, 2004)	Outlines assessment methodology for background noise monitoring and meteorological parameters for modelling purposes.
Assessment of Low Frequency Noise (EHP, Draft, 2013)	Outlines applicable low frequency noise criteria and assessment methodology.
Road Traffic Noise Management: Code of Practice (TMR, 2008)	Outlines road traffic noise criteria for State-controlled roads.
British Standard BS 6472:1992 Evaluation of human exposure to vibration in buildings	Outlines vibration criteria for assessment of annoyance/human comfort.
German Standard DIN 4150-3 1999 Structural Vibration – Part 3: Effects of vibration on structures	Outlines vibration criteria for assessment and protection against building damage.
Noise Measurement Manual (EHP, 2000)	Outlines measurement procedures.
Australian Standard AS1055.1:1997 Acoustics - Description and Measurement of environmental noise - General Procedures(Standards Australia, 2006)	AS1055.1:1997 prescribes applicable measurement and analysis procedures.

Guideline/Standard	Applicability
Noise and vibration from blasting (EPA, 2006)	Specifies recommended human comfort criteria that can be used to set criteria for blasting activities, should it be required.
Australian Standard AS 2187.2-2006 Explosives – Storage and Use, Part 2 Use of Explosives (Standards Australia, 2006)	Outlines best practice blast design and drill and blast practice, should it be required.

3.2 Santos GLNG corporate policy and standards

Corporate policy and standards being implemented for the GLNG Project address noise and vibration issues within the gas fields.

3.2.1 Environmental policy

Santos GLNG is committed to the continuous improvement of environmental performance. To do this, Santos GLNG will comply with relevant legal and other requirements, continuously improve the corporate Environment, Health and Safety Management System and proactively identify environmental hazards, assess their risk and eliminate or, if not practical, manage the risk to as low as reasonably practicable.

3.2.2 EHS12: Noise emissions

The corporate Environment Health and Safety Management System provides a structured framework for effective environmental and safety practice across its activities and operations. Under this system, the issue of noise is addressed through Environmental Hazard Standard EHS12: Noise emissions.

EHS12 describes the controls associated with the management of noise emissions, consisting of noise source identification, risk assessment and management of intrusive noise. This standard applies to Santos GLNG operations that may result in adverse impacts on the surrounding environmental values.

The purpose of EHS12 is to define the requirements for managing noise emissions from activities that may result in adverse impacts on the surrounding environment. Key requirements of this standard include:

- Identify major sources of noise generated during every stage of the operation, including construction, operations and decommissioning, and consider the potential for noise levels to impact on external stakeholders, including stock and wildlife.
- Develop a noise management strategy where it has been identified that noise levels associated with Santos GLNG's operations have the potential to affect external stakeholders or exceed regulatory requirements.
- Conduct baseline surveys, including background level monitoring, in order to establish acceptable limits in accordance with legislative requirements.
- Register complaints in the Complaints Register.

3.2.3 GFD Project Environmental Protocol for Constraints Planning and Field Development

The constraints approach is based upon the *GFD Project environmental protocol for constraints planning and field development* (Constraints protocol) (Santos GLNG, 2014). The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to:

- Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation
- Support Santos' environmental policies and the General Environmental Duty (GED) as outlined in the EP Act

- Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances
- Minimise cumulative impacts on environmental values.

The Constraints protocol details the process that Santos GLNG will use to identify, assess and manage potential impacts to the environment during field planning and development. This process has been successfully used for the approved GLNG Project, which increases the certainty of GFD Project environmental outcomes.

The general principles of the Constraints protocol, in order of preference, are to:

- Avoid — avoid direct and indirect impacts
- Minimise — minimise potential impacts
- Mitigate — implement mitigation and management measures to minimise adverse impacts
- Remediate and rehabilitate — actively remediate and rehabilitate impacted areas
- Offset — offset residual risk in accordance with regulatory requirements.

Consistent with Santos GLNG's environmental management hierarchy, the Constraints protocol prioritises avoidance of environmental impact during field planning by identifying those areas that are not amenable to development. This includes areas of high environmental value as identified in regulatory frameworks and Santos GLNG's baseline surveys. For areas that are considered appropriate to develop, Santos GLNG will identify impacts to environmental values that could potentially occur due to the construction, operations and decommissioning activities of the GFD Project, and determine pre-mitigated impacts (i.e. those that would occur without mitigation).

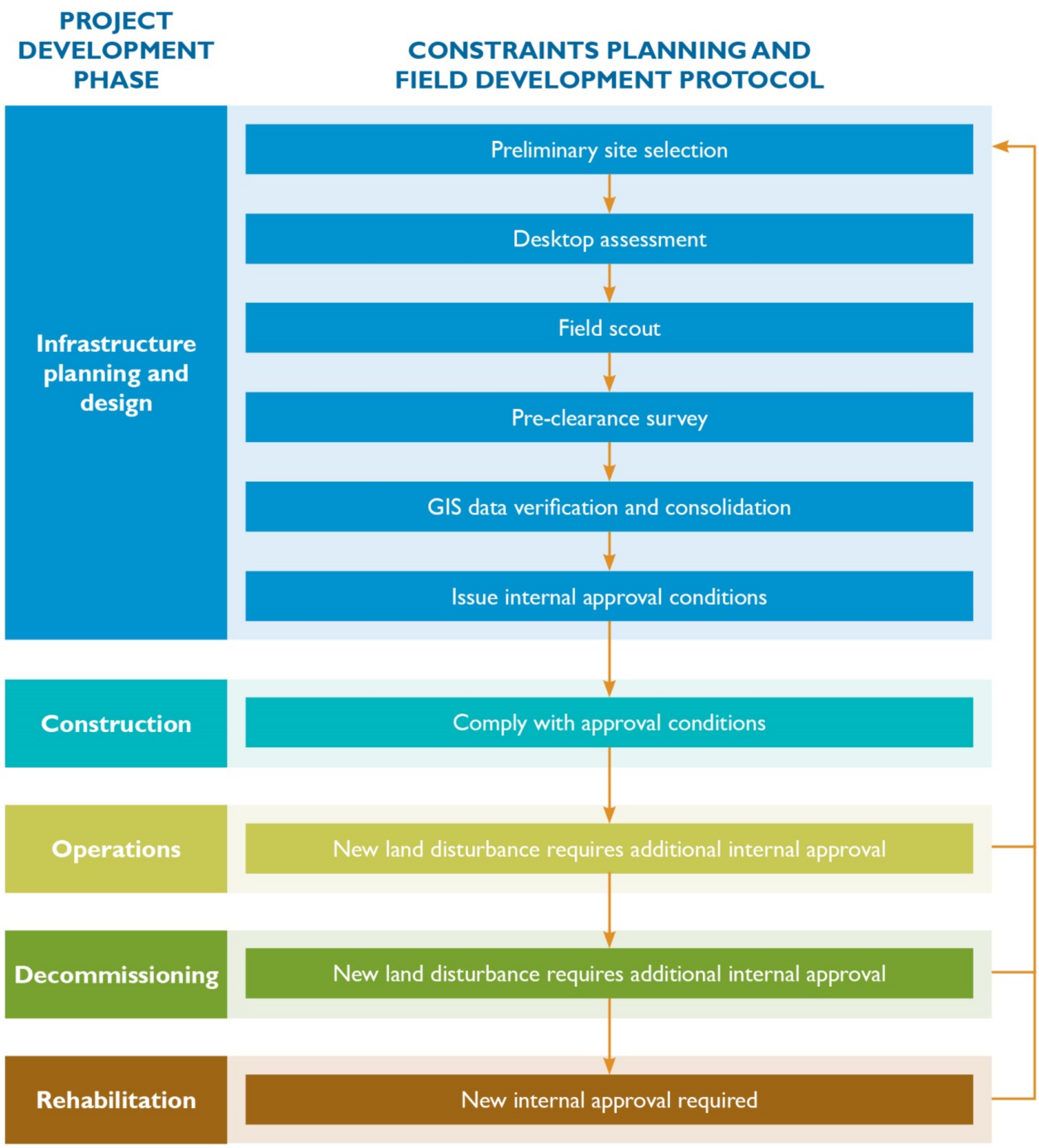
Relevant mitigation and management measures based on the approved environmental management framework already implemented for the GLNG Project are then applied to the pre-mitigated impacts to identify the mitigated (residual) impacts. This process increases certainty about potential impacts by identifying those areas that are not amenable to development, and for those areas where development could occur, how development should proceed.

The post-EIS field development process is a continuation of the field planning process and will be ongoing throughout the life of the GFD Project. The field development process will inform the GFD Project's design, together with a range of other factors including technical feasibility, cost and risk as required by standards applicable to the design, construction, operations, decommissioning and rehabilitation of gas developments. This information will be used to support the subsequent approvals process such as environmental approval application and the plan of operations.

The tasks involved in the field development process are summarised in **Figure 3**.

Once GFD Project infrastructure locations are known, asset-specific management plans and mitigation measures will apply to construction, operation, decommissioning and rehabilitation. Relevant management plans for addressing noise and vibration issues are described in further detail in **Section 7**.

Figure 3 Field development process



4 EXISTING ENVIRONMENTAL VALUES

4.1 Baseline noise surveys from previous studies

Surveys of environmental noise levels within the Surat and Bowen basins were undertaken in 2008 as part of the EIS for the GLNG Project (2009 EIS).

As part of these surveys, long-term ambient noise levels were continuously measured using noise loggers to quantify the existing day-time (7:00 am to 6:00 pm), evening (6:00 pm to 10:00 pm) and night-time (10:00 pm to 7:00 am) noise levels. Short-term measurements were undertaken at the logger locations to characterise the noise environments and determine influences to the measured noise levels.

The measured noise levels are indicative of the noise environments at receptors within the rural regions of the GFD Project and have been applied in this assessment to quantify the baseline noise environment and establish noise criteria.

In addition to the long-term ambient noise monitoring undertaken for the 2009 EIS, ambient noise monitoring was undertaken for the Australia Pacific LNG (APLNG) Project EIS (APLNG EIS) in 2009. A number of noise monitoring locations used for the APLNG EIS are considered relevant for the GFD Project due to their location with respect to the GFD Project area.

The noise monitoring locations are detailed in **Table 3** and are shown on **Figure 4**. Even though, as shown in **Figure 4**, there are no specific noise monitoring surveys undertaken for the Scotia gas field, the noise monitoring undertaken is representative of the typical rural environment dominating throughout the GFD Project area, including the Scotia gas field.

Table 3 Baseline noise monitoring locations – 2009 EIS and APLNG EIS

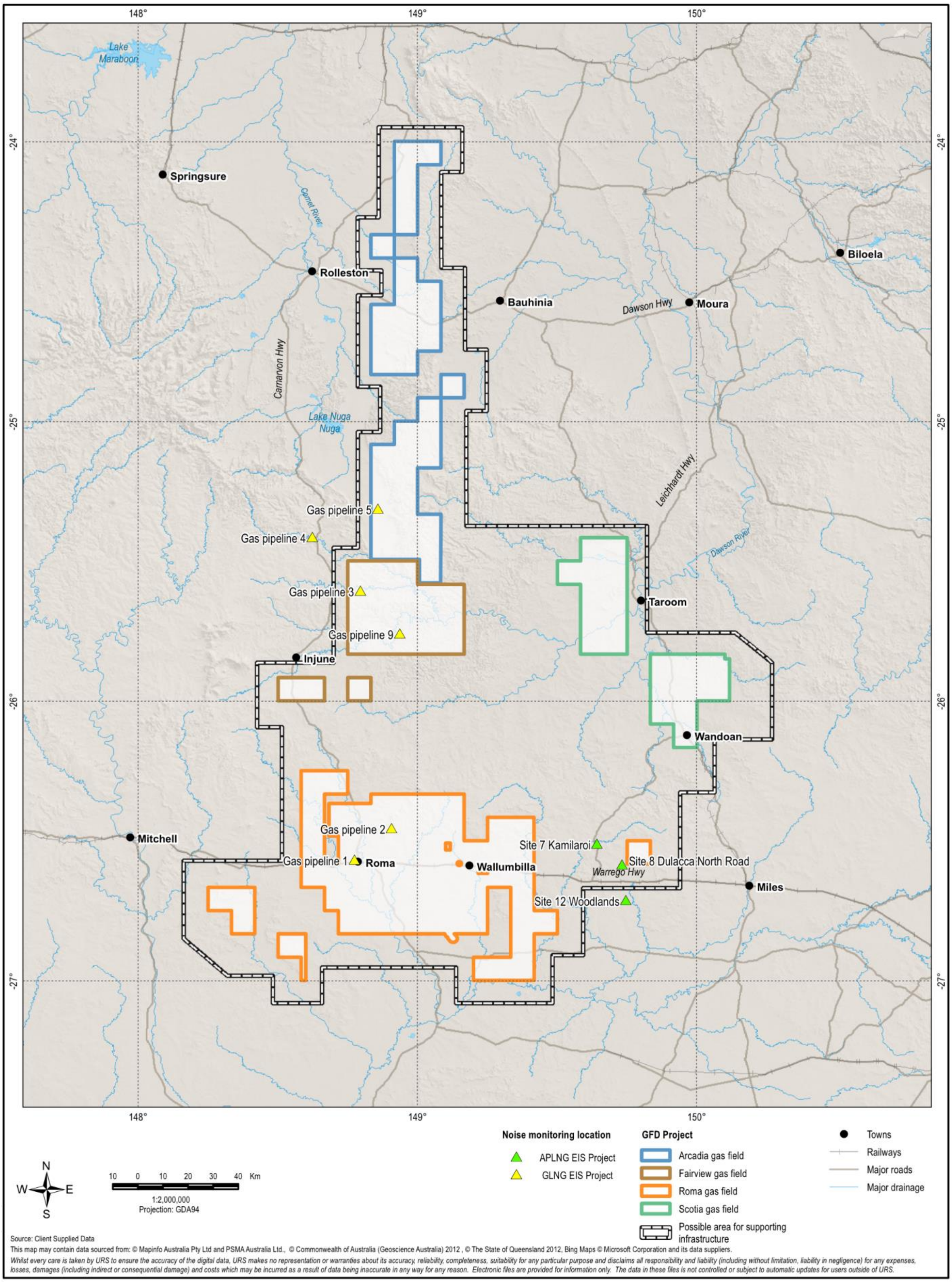
Location[1]	Coordinates	
2009 EIS[2]		
Gas pipeline 1	-26.565928	148.773695
Gas pipeline 2	-26.452863	148.906830
Gas pipeline 3	-25.604078	148.794973
Gas pipeline 4	-25.412463	148.623078
Gas pipeline 5	-25.311035	148.857967
Gas pipeline 9	-25.756953	148.936257
APLNG EIS [3]		
Site 7 Kamilaroi	-26.5084	149.6421
Site 8 Dulacca North Road	-26.5830	149.7317
Site 12 Woodlands	-26.7105	149.7455

Note 1: Monitoring locations are away from existing facilities and representative of typical background noise levels in the area without contribution from existing GLNG or APLNG related facilities.

Note 2: Santos GLNG EIS Noise and Vibration (Terrestrial) 20-2014-R1 (SLR, 2009)

Note 3: *Australia Pacific LNG Project, volume 5: Attachment 32: Noise and Vibration Impact Study – Gas Fields* (Savery and Associates, 2009).

Figure 4 Baseline noise monitoring locations – GLNG EIS and APLNG EIS



Source: URS, 2013; File number 42627064-g-2043.mxd

4.1.1 Noise monitoring methodology

The noise monitoring equipment and methodologies applied in the surveys undertaken for the 2009 EIS and APLNG Project EIS were consistent with the following guidance:

- EPP Noise.
- Queensland Environmental Protection Authority's (EPA) *Noise Measurement Manual* (2000).
- AS1055.1-1997 *Acoustics – Description and measurement of environmental noise, Part 1: General Procedures*.
- AS1259.2-1990 *Sound Level Meters*.

Noise monitoring equipment was calibrated before and after each measurement and no significant drift (±1 decibel (dB)) in calibration signal was observed. The measured noise levels were filtered for periods of unsatisfactory meteorological conditions of wind speed greater than 5 metres per second (m/s) and precipitation events greater than 0.3 millimetres (mm) per 15-minute period.

4.1.2 Characterisation of the local noise environment

To identify the noise sources contributing to the long-term unattended monitored noise levels at each noise monitoring location, short-term attended noise measurements were made, where practicable, during the daytime, evening and night-time periods. The attended measurements, made with hand held sound level meters, are detailed in **Table 4** with commentary on the observed noise sources. No attended noise monitoring was presented for the APLNG Project EIS.

The existing noise levels at the monitoring locations were primarily influenced by local birds and insect activity consistent with the rural environment in the GFD Project area. Depending on the proximity to local and main roads, intermittent local road traffic movements and distant road traffic noise from Currey Street – Roma, Warrego Highway and the Carnarvon Highway was audible during the daytime and evening periods. It is assumed that no significant road traffic noise is audible during night-time.

Table 4 Baseline attended ambient measurement results – 2009 EIS[1]

Monitoring location	Date	Time (end of 15 min period)	Measured noise level (dBA)			Comments
			LA90	LAeq	LA10	
Gas pipeline 1	16/06/08	9:45 am	41	60	60	Traffic along Currey St dominant noise source; noise from nearby construction activities; birds active.
	16/06/08	6:15 pm	43	57	57	Traffic along Currey St dominant noise source; birds and insects active (dominant with no traffic).
	16/06/08	11:15 pm	34	38	40	Insects and bird noise; distant traffic noise (not Currey St, possibly Warrego Hwy/ main street through Roma).
Gas pipeline 2	16/06/08	2:45 pm	20	32	32	Insects and birds dominant; One passing 4WD. Very quiet at this location.
	16/06/08	9:45 pm	17	23	19	Very quiet at this locations. Minor bird noise.
	16/06/08	10:30 pm	16	29	19	Very quiet at this locations. Minor bird noise.
Gas pipeline 3	17/06/08	12:45 pm	27	42	37	Birds active and dominant; minor insect noise; truck pass-by on Fairview Rd (55-65 dBA); light tree movement with breeze

Monitoring location	Date	Time (end of 15 min period)	Measured noise level (dBA)			Comments
			LA90	LAeq	LA10	
Gas pipeline 4	17/06/08	17:45 pm	26	40	41	Birds, insects and cow noise dominant noise sources. Distance traffic just audible (trucks ~ 35 dBA).
	17/06/08	6:15 pm	19	34	34	Insect, bird and cow noise dominant though not loud; distant traffic on Carnarvon Hwy audible (truck ~ 35-40 dBA, car ~25-32 dBA)
Gas pipeline 5	17/06/08	3:15 pm	21	30	32	Insects and birds dominant; light tree movement in breeze; 4WD drove by on dirt road (45-47 dBA over 15 seconds)
Gas pipeline 9	15/07/08	10:45 am	28	36	39	Birds dominant, light tree movement. Passing 4WDs audible (~38-42 dBA), 5 pass-bys in 15 min block. Distant noise from construction activities.

Note 1: Santos GLNG EIS Noise and Vibration (Terrestrial) 20-2014-R1 (SLR, 2009)

Based on these measurements, noise from gas field operations was not audible at the noise monitoring locations during the daytime, evening or night-time periods.

4.1.3 Long-term measured noise levels

The measured ambient noise levels were applied to determine the Rating Background Level (RBL) for the daytime, evening and night-time periods. The RBL is the median of the 90th percentile background (L_{A90}) noise levels for each period over the duration of the monitoring. Where the measured noise levels were below the measurement threshold of the noise loggers, the RBLs were 'adjusted' (reduced) to provide a representative measurement of the noise environment.

Analysis of the measured noise levels has determined hourly (L_{Aeq}) noise levels at each noise monitoring location. The L_{Aeq} noise descriptor is more sensitive than the L_{A90} descriptor to short-term and peak noise generating events and is applied as a measurement of the steady noise level over the monitoring period.

Detailed in **Table 5** are the adjusted RBLs and hourly ambient background noise levels for the monitoring locations.

Table 5 Rating background levels and ambient noise levels (2009 EIS and APLNG EIS)

Location[1]	Adjusted RBL dBA			Maximum $L_{Aeq(1hour)}$ dBA		
	Day	Evening	Night	Day	Evening	Night
2009 EIS[2]						
Gas pipeline 1	37	34	28	58	53	55
Gas pipeline 2	23	18[4]	17[4]	55	45	45
Gas pipeline 3	24	18[4]	18[4]	54	37	41
Gas pipeline 4	27	19[4]	18[4]	52	38	43
Gas pipeline 5	21[4]	18[4]	17[4]	46	29	40
Gas pipeline 9	30	29	29	49	40	47
APLNG EIS[3]						
Site 7 Kamilaroi	20	<15[4]	<15[4]	37	27	<15[3]
Site 8 Dulacca North Road	19	<15[4]	<15[4]	33	20	18
Site 12 Woodlands	25	<15[4]	<15[4]	42	27	21

Note 1: Monitoring locations were away from existing facilities and representative of typical background noise levels in the area without contribution from existing GLNG Project or APLNG Project-related facilities.

Note 2: Santos GLNG EIS Noise and Vibration (Terrestrial) 20-2014-R1 (SLR, 2009)

Note 3: *Australia Pacific LNG Project, volume 5: Attachment 32: Noise and Vibration Impact Study – Gas Fields* (Savery and Associates, 2009)

Note 4: Measured RBL adjusted for the measurement threshold of the noise logger.

The long-term measured noise levels follow typical diurnal pattern with noise levels reduced during the evening and night-time periods when bird, insect and road traffic activity is negligible.

Measured RBL of below 30 dBA (L_{A90}) during the daytime and RBL below 20 dBA (L_{A90}) during the evening and night-time are low and characteristic of rural environments with minimal noise influences. The range represented by the loudest one hour (maximum $L_{Aeq(1hour)}$) may be associated with passing traffic on nearby roads (e.g. Gas pipeline 1), animal noise, wind in nearby vegetation, domestic noise or dog barking.

Measurements of background noise levels for the 2009 EIS and APLNG EIS were both conducted during the cooler winter months. The ambient acoustic environment is likely to more often contain additional insect noise during the warmer months of the year. The potential for noise impacts is greater during the winter months when background noise levels are lower at night. On this basis, the background noise measurements presented in **Table 5** represent the worst case in terms of seasonal variations.

Based on the existing noise environment with typically very low background noise levels, the nearest sensitive receptors and communities to the GFD Project may be sensitive to the level and characteristic of audible noise from the GFD Project.

4.2 Deemed background noise levels

In accordance with the noise assessment guideline *Prescribing Noise Conditions for Petroleum and Gas Activities* (EHP, 2012), there are deemed backgrounds to be used in the determination of noise limits in rural areas where background noise levels can be very low. The intent of the deemed background noise levels are to achieve a balance between economic development and environmental protection required by the EP Act. The deemed background noise levels are presented in **Table 6**.

Table 6 Deemed background noise levels

Time period	Deemed background noise level (dBA)
7:00 am – 6:00 pm (day)	35
6:00 pm – 10:00 pm (evening)	30
10:00 pm – 6:00 am (night)	25
6:00 am – 7:00 am (morning)	30

By comparing the deemed backgrounds in **Table 6** with the measured background noise presented in **Table 5,** it can be seen that the measured backgrounds are lower than the deemed backgrounds for each monitoring location except Gas pipeline 1. This location is within the township of Roma and had noise from the Warrego Highway in the distance. While it is likely that a small proportion of noise sensitive receptors associated with the GFD Project, which are located near to highways or townships, may have background noise levels higher than the deemed backgrounds, it is not practical to consider higher backgrounds until location-specific background measurements are conducted during future stages of the GFD Project. In accordance with the noise assessment guideline *Prescribing Noise Conditions for Petroleum and Gas Activities* (EHP, 2011) the deemed background noise levels have been adopted for noise sensitive receptors associated with the GFD Project.

4.3 Existing ground vibration levels

Existing ambient ground vibrations are not expected to be perceptible at the vast majority of sensitive receptors in the GFD Project area. The exceptions to this would be sensitive receptors located near mines and quarries that conduct blasting. Existing and future planned mining projects in the GFD Project area that may include blasting is included in **Appendix B**. Other sources of ground vibration would be industry, construction and heavy transport corridors. These activities generally only result in perceptible ground vibrations within very close proximity (within 70 m) to the vibration source and therefore it is unlikely that many sensitive receptors within the GFD Project are currently exposed to ground vibrations from these sources.

5 ASSESSMENT METHODOLOGY

The approach used in this assessment has been designed to provide a conservative assessment of noise emissions against selected assessment criteria at various distances for the assessed construction, operations and decommissioning scenarios.

The results of this modelling have been used to determine potential impact distances from nearby sensitive receptors where further noise management and mitigation measures are not required for each assessed scenario. Where sensitive receptors are located within the determined potential impact distances, further noise management and mitigation measures have been outlined in **Section 7**.

Once preferred locations for individual major facilities (such as gas compression facilities) are identified, and more details of the required size and number of equipment are known, more detailed modelling would be performed to enable location-specific factors such as the surrounding topography and land use to be accounted for in the modelling to quantify the impacts of these factors on the predicted noise and vibration levels.

Details of the methodology and modelled scenarios are provided in the following sections.

5.1 Assessment criteria

5.1.1 Construction and operations noise criteria

In February 2012, the EHP published *Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities* (Noise Assessment Guideline) to supplement the application of EPP Noise in the administration of an environmental authority for petroleum and gas activity projects.

This guideline applies to the GFD Project as it specifies best practice noise limits, which are considered to protect the acoustic values of a sensitive receptor in rural or isolated areas and achieve acoustic quality objectives set out in the EPP Noise, whilst considering cumulative impacts and background creep.

The best practice noise emission limits are reproduced in **Table 7**. These best practice noise limits are applicable to noise emissions from construction/decommissioning and operation, the duration and work hours of the activity determining the applicable noise limit for the activity. The best practice noise limits are based on the deemed background noise levels (refer **Table 6**), where higher background noise levels are monitored higher noise limits may apply.

Table 7 Best practice noise limits

Time period	Parameter	Noise limit (dBA)[1]		
		Short-term[2]	Medium-term[3]	Long-term[4]
7:00 am – 6:00 pm	$L_{Aeq, adj, 15mins}$	45	43	40
6:00 pm – 10:00 pm	$L_{Aeq, adj, 15mins}$	40	38	35
10:00 pm – 6:00 am	$L_{Aeq, adj, 15mins}$	28	28	28
	Max $L_{pA, 15 mins}$	55	55	55
6:00 am – 7:00 am	$L_{Aeq, adj, 15mins}$	40	38	35

Note 1: Based on the deemed background noise levels in **Table 6**.

Note 2: A short-term noise event is defined as a noise exposure lasting for no greater than eight hours and does not reoccur for at least seven days.

Note 3: A medium-term noise event is defined as a noise exposure lasting for no greater than five days and does not reoccur for at least four weeks.

Note 4: A long-term noise event is defined as a noise exposure lasting for greater than five days, even when there are respite periods when noise is inaudible within those five days. Most construction and operations scenarios will fall within this long-term noise event specification.

The Australia Environmental Health Committee (enHealth) (2004) was also considered. However, the best practice noise limits in **Table 7** are below the most stringent of the World Health Organisation (WHO) noise levels referenced in enHealth, and are hence considered adequate to protect sensitive receptors from adverse health effects. Further discussion on the recommendations in enHealth is documented in **Appendix C**.

5.1.2 Low frequency noise

Low frequency noise ranges from approximately 20 hertz (Hz) to 200 Hz. Low frequency noise from the operation of the GFD Project will be assessable in accordance with the EHP's draft guideline, *Assessment of Low Frequency Noise* (EHP, 2013). The 2013 issue is the latest publically available version of the EHP's draft low frequency noise guideline and as such has been used for this assessment. The intent of this guideline is to accurately assess annoyance and discomfort to persons at noise sensitive places.

The draft guideline's assessment procedure involves a two-part screening test, following receipt of a low frequency noise-related complaint. To establish the potential of high levels of low frequency noise inside dwellings, the following methodology applies:

a. The overall sound pressure level inside residences should not exceed 55 dBZ; and, if (a) is true

b. The difference between the interior dBZ value and the interior dBA value exceeds 15 dB.

Where (b) is subsequently found to be true, the draft guideline states that there is a risk for low frequency noise impact and a detailed one third octave band analysis should be performed to establish impact.

For this assessment, the initial screening test has been undertaken, using an outdoor screening level of 60 dBZ L_{Zeq} (assumes 5 dB facade reduction), to investigate if there is potential for low frequency noise impacts from the GFD Project.

5.1.3 Fauna

Noise can have adverse effects on wildlife and domesticated mammals, with different species being more or less sensitive to noise. As with humans, extremely high noise levels can result in hearing damage or other physiological effects. Even at lower noise levels, which will not cause hearing damage it seems likely that animals avoid anthropogenic noise sources and prefer to occupy areas further from noise sources.

On the basis of the literature, and noting the difficulties inherent in assessing noise impacts on fauna described in **Appendix D**, the following conclusions are drawn:

- Adverse impacts on fauna are highly unlikely at noise levels below 50 dBA L_{Aeq}, and unlikely at noise levels below 65 dBA L_{Aeq}.
- Long-term adverse impacts on fauna are unlikely to arise from short duration, high noise events. These events may, however, result in a short-term startle response.
- Very high maximum noise levels may result in hearing loss or other long-term physiological effects. The threshold of hearing damage is likely to be species and frequency dependent, and as with humans, damage may be cumulative over time.

With reference to the GFD Project, it is considered that fauna (including domesticated mammals) exposed to less than **65 dBA L_{Aeq}** are unlikely to experience adverse impacts.

5.1.4 Road traffic noise

The EP Act and subordinate regulations do not contain noise criteria applicable to traffic noise. Schedule 1, Part 1 of the EP Act excludes traffic noise from public access roads and State-controlled roads from being a noise nuisance offence in accordance with the EP Act. This study has adopted the noise criteria contained in the TMR *Road Traffic Noise Management: Code of Practice* (TMR Code of Practice) for GFD Project related traffic on State-controlled roads.

TMR Code of Practice

The TMR Code of Practice provides details for the assessment of road traffic noise from State–controlled roads. Different criteria and priorities apply depending on the road type (new or existing, access/non-access controlled roads) and to receptor/land usage type (residential, educational and health, or parks and other recreational facilities).

For existing residential premises adjacent to a new road, the TMR Code of Practice noise objective is 63 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

For existing residential premises adjacent to an existing or upgraded road, the TMR Code of Practice noise objective is 68 dBA $L_{A10(18hour)}$ within a 10 year post-construction period.

Incremental change in road traffic noise levels

Where the GFD Project is adding vehicles to an existing or upgraded road it is appropriate to consider the incremental change in noise levels due to the changes in traffic volume.

A change of up to 3 dBA in the level of a dynamic noise such as passing vehicles is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness.

SLR acknowledge that people are likely to notice increased traffic based on visual clues and perception of vehicle pass-by frequency before they will objectively notice an increase in the average noise level.

For assessment purposes it is common to set the threshold of significance in relation to changes in the noise emission level from roads at 2 dBA.

Summary of road traffic noise criteria

The road traffic noise criteria for the GFD Project are summarised in **Table 8**.

Table 8 Summary of road traffic noise criteria

Road type		Criteria
State road	Existing road	68 dB $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New road	63 dB $L_{A10(18hour)}$
Public road[1]	Existing road	63 dB $L_{A10(18hour)}$ and ≤ 2 dBA change in existing $L_{A10(18hour)}$
	New road	63 dB $L_{A10(18hour)}$

Note 1: Public roads are non-private Council-controlled roads.

5.1.5 Vibration criteria

When dealing with vibration from construction and operations, the effects in buildings can be divided into the following main categories:

- Human comfort
- Structural damage
- Safe vibration levels for common services
- Effects of vibration on building contents.

The relevant vibration criteria for each of these categories are outlined in **Appendix E**.

A summary of applicable vibration criteria at sensitive receptors associated with the construction and operation of the GFD Project is shown in **Table 9**.

Table 9 Vibration criteria

Receptor type	Cosmetic damage due to continuous vibration (mm/s PPV)	Human comfort (mm/s PPV)	Sensitive building contents (mm/s PPV)
Residential	7.5	According to AS 2670 refer to **Table D1**	-
Commercial	7.5	According to AS 2670 refer to **Table D1**	0.5[1]

Note 1: Equipment specific vibration criteria may be required for highly sensitive equipment (i.e. electron microscopes, MRI systems or similar), as part of future location-specific detailed investigations.

5.2 Modelling software and prediction standards

5.2.1 SoundPLAN

In order to calculate the noise emission levels at the various noise sensitive receptor locations, a SoundPLAN (Version 7.2) environmental computer model was developed. SoundPLAN is a software package that enables compilation of a sophisticated computer model comprising a digitised ground map (containing ground contours), the location and acoustic sound power levels (SWL) of potentially critical noise sources and the location of sensitive receptors for assessment purposes.

The computer model can generate noise emission levels taking into account such factors as the source SWLs and locations, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions such as wind effects.

5.2.2 CONCAWE

Noise predictions for this EIS have been carried out using the CONCAWE prediction methodology within SoundPLAN, with the exception of road traffic noise predictions (which have been carried out using the Calculation of Road Traffic Noise (CoRTN) 1988 prediction method).

The CONCAWE prediction method is specially designed for large facilities and incorporates the influence of wind effects and the stability of the atmosphere.

The statistical accuracy of environmental noise predictions using CONCAWE was investigated by Marsh (1982). Marsh concluded that CONCAWE was accurate to ±2 dBA in a one octave band between 63 Hz and 4 kHz and ± 1 dBA overall.

Noise levels have been calculated for both neutral and adverse weather conditions where appropriate. The adverse weather condition parameters used to assess the effect of adverse meteorological conditions such as temperature inversions on noise propagation is shown in **Table 10** below. These parameters are considered typical of neutral and adverse weather in regards to noise propagation. For more details regarding weather conditions and meteorological parameters for the study area, the air quality report for the GFD EIS (Appendix P:*Air Quality*) includes a more comprehensive meteorological assessment.

Table 10 Weather conditions – neutral and adverse

Parameter	Neutral weather	Adverse weather
Temperature	10°C	10°C
Humidity	70%	90%
Pasquill stability category	D	F
Wind speed	0 m/s	2 m/s (source to receptor)

5.2.3 CoRTN road traffic noise prediction method

The CoRTN prediction technique was used to calculate the road traffic noise levels from the GFD Project (and the change in road traffic noise levels).

These calculations account for traffic volumes, composition, vehicle speed, and road surface. CoRTN is the recommended road traffic noise prediction technique in TMR's Code of Practice.

5.3 Construction

The assessment methodology for determining noise and vibration impacts associated with the construction phase of the GFD Project is discussed in the following sections. The following construction scenarios have been assessed:

- Drilling and completion (with and without blooie line operation)
- Facilities (such as hub and nodal gas compression facilities)
- Gathering/transmission lines (gas and water)
- Borrow pits
- Laydown areas
- Communication infrastructure
- Roads/access tracks.

The drilling and completion scenario has been modelled both with and without the blooie line operating. The blooie line is a surface pipe that discharges air, water and well cuttings during drilling operations. The higher noise emission from the blooie line is mostly during the primary jet discharge, which lasts for a few minutes when connecting a new drill pipe to the drill string.

Road traffic noise impacts associated with the construction phase of the GFD Project are discussed in **Section 5.5**.

5.3.1 Construction equipment noise sources

Equipment to be used for the GFD Project construction phase and the relevant construction modelling scenarios are discussed in the following sections. The construction SWLs and relevant construction modelling scenarios have been used to predict the acoustic footprint of construction activities throughout the GFD Project.

Predicted construction noise levels will inevitably depend upon the number of plant items and equipment operating at one time and on their precise location relative to the sensitive receptor(s). Therefore a sensitive receptor will experience a range of values representing “minimum” and “maximum” construction noise emissions depending upon:

- The location of the particular construction activity (i.e. if the plant item of interest were as close as practical to or further away from the sensitive receptor of interest)
- The likelihood of the various items of equipment operating simultaneously.

The noise assessment methodology has been based on predicting noise levels at various distances, assuming propagation over flat, soft ground (i.e. open grassland) to a typical sensitive receptor.

For construction activities that are likely to occur 24 hours a day (this will generally only include drilling and completion), noise level predictions have been undertaken for neutral and adverse meteorological conditions (where temperature inversion are considered applicable).

For construction activities that generally occur during the daytime only (i.e. gas compression facilities, gathering/transmission lines, borrow pits, laydown areas, communication infrastructure and roads/access track construction), noise level predictions have been undertaken for neutral meteorological conditions as temperature inversion are not considered applicable for day-time works. It is possible that in some instances a limited or a reduced set of construction activities rather that the full suite of noise sources could occur outside daytime hours. For these instances specific predictions would be undertaken to ensure the noise criterion is achieved at the nearest sensitive receivers.

The SWLs shown in **Appendix F** are noise emission levels for construction plant associated with the GFD Project.

5.3.2 Construction scenarios and activities

The assessed construction scenarios and stages are summarised in **Table 11** and outlined in more detail including plant and equipment in **Appendix G**.

Table 11 Construction scenarios and stages

Construction scenario	Construction activity
Drilling and completion	Well lease construction
	Drilling rig
	Hydraulic fracturing
	Completions rig
Facilities (such as hub and nodal gas compression facilities)	Clear and grade
	Concrete pad and foundations
	Set up facilities
	Construct compressors and coolers
Gathering/transmission lines	Clear and grade
	Stringing
	Welding and joint coating
	Pressure testing
	Trenching
	Lowering of pipe
	Padding and backfilling
	Tie-ins, push sections and road crossings
	Restoration and rehabilitation
Borrow pits	Excavating material
Laydown areas	Clear and grade
	Laydown yard operations
Communication infrastructure	Clear and grade
	Civil works
Roads/access tracks	Clear and grade
	Civil works

5.4 Operation

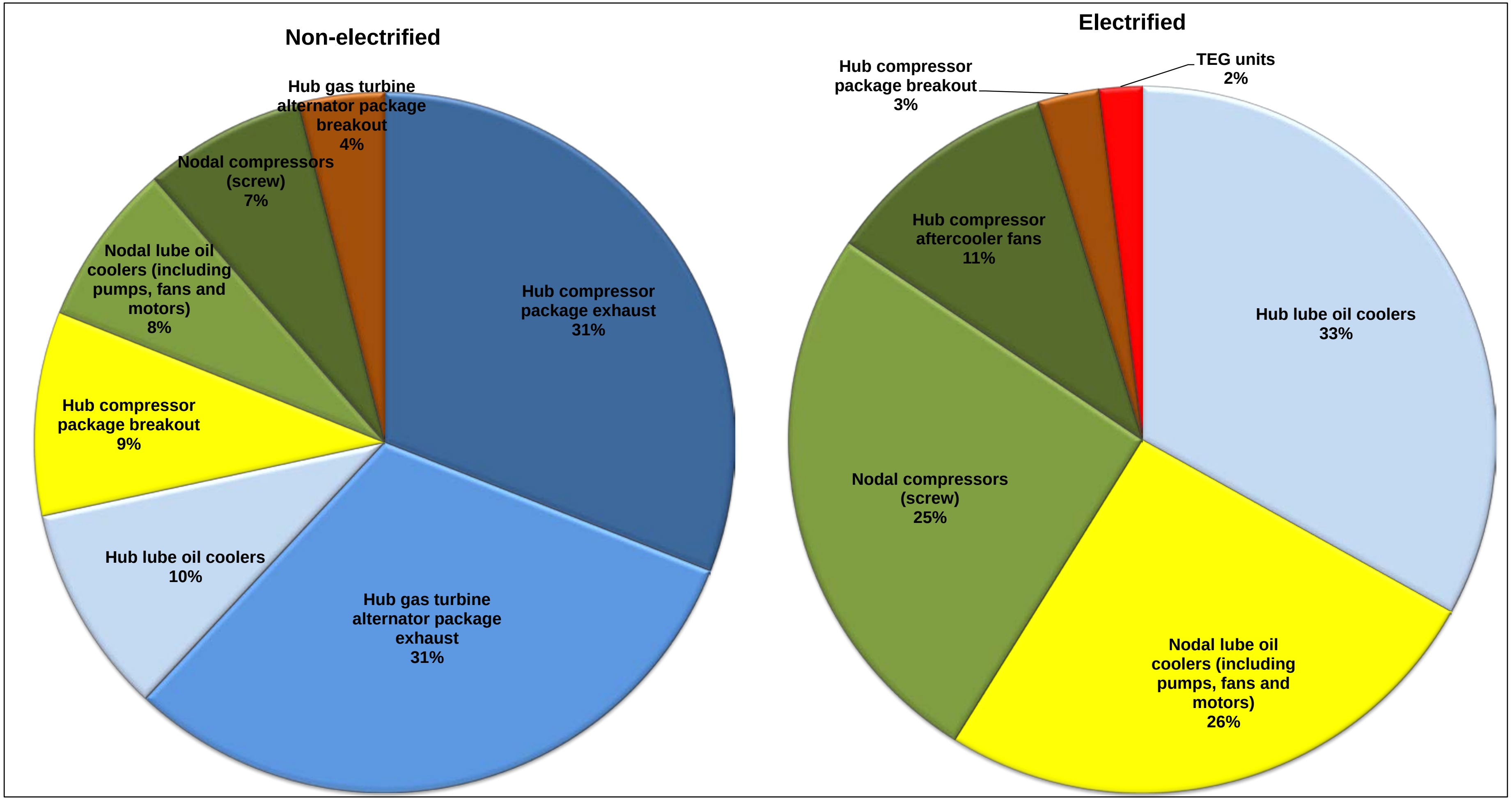
The methodology for assessing noise and vibration impacts associated with the operations phase of the GFD Project is discussed in this section. The following operations scenarios have been assessed:

- Hub gas compression facility (non-electrified)
- Hub gas compression facility (electrified)
- Nodal gas compression facility (non-electrified)
- Water treatment facility
- Well (non-electrified)
- Well (electrified or free flowing)
- Gas compression facility – flaring
- Accommodation camp (400 man camp assumed).

The above operations scenarios are assumed to occur 24 hours a day and noise level predictions have therefore been undertaken for neutral and adverse meteorological conditions.

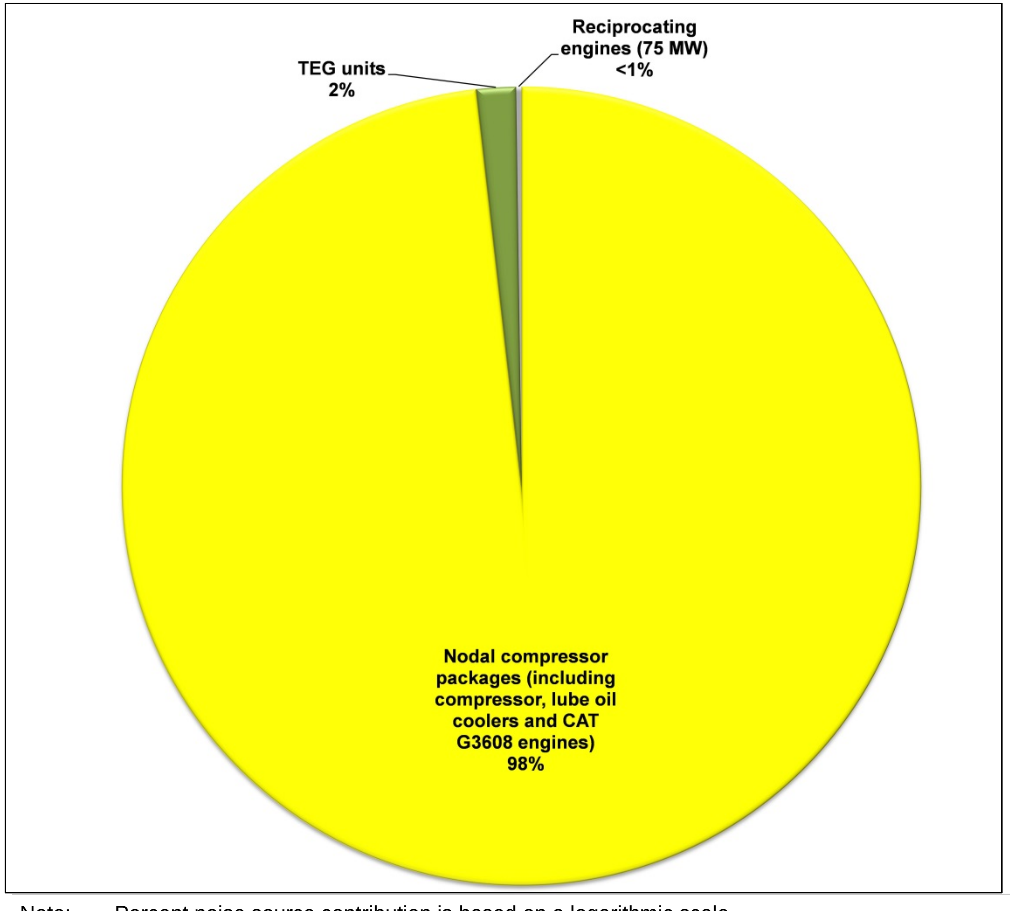
A full listing of the equipment specifications and number of equipment and associated SWL for each of the above operation scenarios are detailed in **Appendix H**. The dominant noise sources are the exhausts for the gas turbine and engines which drives compressors and alternators at the hub and nodal gas compression facilities as shown in **Figure 5** and **Figure 6** for respectively. **Figure 5** and **Figure 6** present the incremental noise emissions accounting for the number of units present.

Figure 5 Noise source contribution – hub gas compression facility



Note: Percent noise source contribution is based on a logarithmic scale.

Figure 6 Noise source contribution – nodal gas compression facility



Note: Percent noise source contribution is based on a logarithmic scale.

5.5 Decommissioning

Once gas supply from gas field is exhausted, surface infrastructure and facilities will be decommissioned and rehabilitated. In addition it is likely throughout the life of the GFD Project that hub and nodal gas compression facilities that are no longer required will also be decommissioned.

Generally decommissioning will consist of disconnection of services and disassembly and removal of equipment and finally grading and soil stabilisation and rehabilitation. This is similar to the construction of these facilities, but in reverse and with slightly lower noise emissions. The construction modelling scenarios in **Section 5.3** will therefore be representative of a conservative assessment for the decommissioning phase.

5.6 Transportation

The assessment methodology for noise and vibration impacts from GFD Project transportation has been performed by the following two methods:

- For State-controlled roads, where traffic volume predictions are available for the GFD Project, road traffic noise levels at different distances from the roads have been predicted.
- For public roads and access roads, where no traffic volume predictions are available for the GFD Project:
  - Assessment of the overall traffic noise level based on assumed GFD Project-related traffic numbers and speeds plotted on a graph. The graph indicates up to what traffic volumes compliance with a particular noise criterion will be achieved.
  - Assessment of the incremental change in traffic noise levels based on assumed GFD Project related traffic and existing traffic volumes plotted on a graph.

5.7 Cumulative impacts

When multiple projects occur in a region, they result in cumulative impacts that differ from those of an individual project when considered in isolation. Cumulative impacts may be positive or negative, and their severity and duration will depend on the project size and timing overlap.

The ToR for this EIS requires an assessment of the GFD Project's cumulative impacts.

Projects for inclusion in this cumulative impact assessment have been designated as those within the GFD Project's tenures and within a 50 km buffer around the tenures (or a greater buffer for some broader reaching values) that:

- Are currently being assessed under Part 1 of the Chapter 3 of the EP Act and as a minimum, an Initial Advice Statement (IAS) is available on the EHP website.
- Have been declared a 'coordinated project' by the Coordinator-General under *the Sustainable Development and Public Works Organisation Act 1971* (Qld) and an EIS is currently being prepared or is complete, and as a minimum, an IAS is available on the Queensland Department of State Development, Infrastructure and Planning website.
- Are high voltage transmission network projects to be operated under the *Electricity Act 1994* (Qld) that will seek approval for the project to be designated as community infrastructure under the *Sustainable Planning Act 2009* (Qld), which are currently being assessed and an EIS is currently being prepared or is complete and information is available on the proponents' website.
- Will, or may, use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the GFD Project.
- Could potentially compound residual impacts that the GFD Project may have on environmental or social values.

Projects that are excluded from the GFD Project's cumulative impact assessment are:

- Existing or historic projects within the project area and surrounding buffers that are considered to constitute part of the baseline environment
- Projects that have not been developed to the point that their environmental assessment process has been made public.

Based on the above criteria, projects that may need to be considered during location specific cumulative impact assessments are summarised in **Appendix B**.

The approach adopted for the cumulative noise impact assessment has been to predict the cumulative increase in noise levels for various distances between GFD Project facilities and other project's facilities. Potential cumulative impacts as a result of multiple GFD Project related sources have also been assessed, including the following:

- Multiple well leases
- Well lease(s) adjacent a gas compression facility
- Co-location of water treatment facility and gas compression facility.

6 ASSESSMENT OF NOISE AND VIBRATION IMPACTS

In order to assess the noise impacts associated with the various construction and operations scenarios, calculations were carried out in order to determine:

- Noise emission levels at various distances from construction and operations scenarios
- Various distances from construction and operation at which the nominated noise emission levels are predicted, including the potential distances to comply with the relevant noise limits without additional management or mitigation.

The noise emissions in **Table 12** to **Table 15** assume propagation over flat, soft ground (i.e. open grassland) to a typical sensitive receptor. The influence of topography and vegetation on calculated noise levels in **Table 12** to **Table 15** are discussed in **Section 6.8**.

Grey highlighted cells in **Table 13** and **Table 15** represent distances where further noise management and mitigation measures may be required. Further noise management and mitigation measures are discussed in **Section 7**. Remaining cells show the predicted distances required to achieve the relevant criteria without further noise management and mitigation measures for each modelled scenario.

6.1 Construction and decommissioning noise

Predicted noise levels at various distances for the construction scenarios are presented in **Table 12**. It is noted that the predictions in **Table 12** and **Table 13** are based on the expected summation of noise sources at the sensitive receptor for the noisiest scenario. As discussed in **Section 5.5**, it is expected that decommissioning activities will result in the same noise impacts as construction, albeit at lower levels. Thus, the construction scenario presents a conservative estimate of decommissioning noise impacts.

Table 12 Predicted noise levels at various distances – construction and decommissioning

Construction scenario	Weather conditions	Predicted noise level with distance (dBA L_{Aeq})[1]						
		50 m	100 m	250 m	500 m	1,000 m	2,000 m	5,000 m
Drilling and completion[2]	Neutral	77 (85)	71 (78)	59 (67)	49 (57)	38 (47)	28 (36)	< 15 (19)
Drilling and completion[2]	Adverse	79 (86)	73 (80)	64 (72)	55 (63)	44 (53)	33 (42)	16 (25)
Facilities	Neutral	75	68	57	48	40	31	15
Gathering/transmission lines	Neutral	72	65	54	45	37	28	< 15
Borrow pits	Neutral	76	70	58	50	42	32	17
Laydown areas	Neutral	70	64	52	43	35	26	< 15
Communication infrastructure	Neutral	70	64	52	43	35	26	< 15
Roads/access tracks	Neutral	67	60	49	41	33	24	< 15

Note 1: The noise levels are predicted based on the expected summation of noise sources at the sensitive receptor for the noisiest construction stage.

Note 2: Values in brackets includes operation of blooie line.

Based on the predicted noise emission levels at various distances shown in **Table 12**, the distances to various noise levels have been presented in **Table 13**.

Table 13 Potential impact distances for various predicted noise levels – construction and decommissioning

Construction scenario	Weather conditions	Distance to predicted noise level (m)[1]								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Drilling and completion[2]	Neutral	200 (300)	350 (600)	450 (850)	650 (1,200)	900 (1,600)	1,300 (2,200)	1,800 (2,900)	2,000 (3,200)	2,400 (3,800)
Drilling and completion[2]	Adverse	250 (450)	500 (900)	700 (1,200)	950 (1,700)	1,300 (2,300)	1,800 (3,100)	2,500 (4,000)	2,800 (4,400)	3,300 (5,100)
Facilities	Neutral	150	300	450	650	1,000	1,500	2,100	2,400	2,900
Gathering/transmission lines	Neutral	150	250	350	550	800	1,200	1,800	2,000	2,500
Borrow pits	Neutral	150	350	500	800	1,200	1,700	2,400	2,700	3,200
Laydown areas	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Communication infrastructure	Neutral	100	200	300	450	650	1,000	1,500	1,700	2,100
Roads/access tracks	Neutral	100	150	250	350	550	850	1,300	1,500	1,900

Note 1: The distances are based on predicted noise levels at 50 m intervals up to 1,000 m and 100 m intervals thereafter.

Note 2: Values in brackets includes operation of blooie line.

Note: Grey highlighted cells represent distances where further noise management and mitigation measures may be required to achieve noise limits. Further noise management and mitigation measures are discussed in **Section 7**.

Table 12 and **Table 13** show that the greatest potential noise impacts are associated with drilling activities. **Table 13** shows that for night-time drilling activities, no further noise management and mitigation measures are required where sensitive receptors are at a distance greater than the following:

- 2,000 m – neutral weather conditions
- 2,800 m – adverse weather conditions.

Table 13 also shows that during blooie line operations, no further noise management and mitigation measures are required where sensitive receptors are at a distance greater than the following:

- 3,200 m – neutral weather conditions
- 4,400 m – adverse weather conditions.

For construction of facilities and infrastructure (i.e. all construction scenarios excluding drilling and completion), no further noise management and mitigation measures are required where sensitive receptors are at a distance greater than 550 m to 1,200 m under neutral weather conditions.

The potential noise impacts from construction activities and equipment sources are managed through the implementation of the management plans detailed in **Section 7**.

6.2 Construction vibration

The following section addresses the potential vibration impacts associated with construction of the GFD Project. The dominant sources of vibration emission from the construction of the GFD Project are:

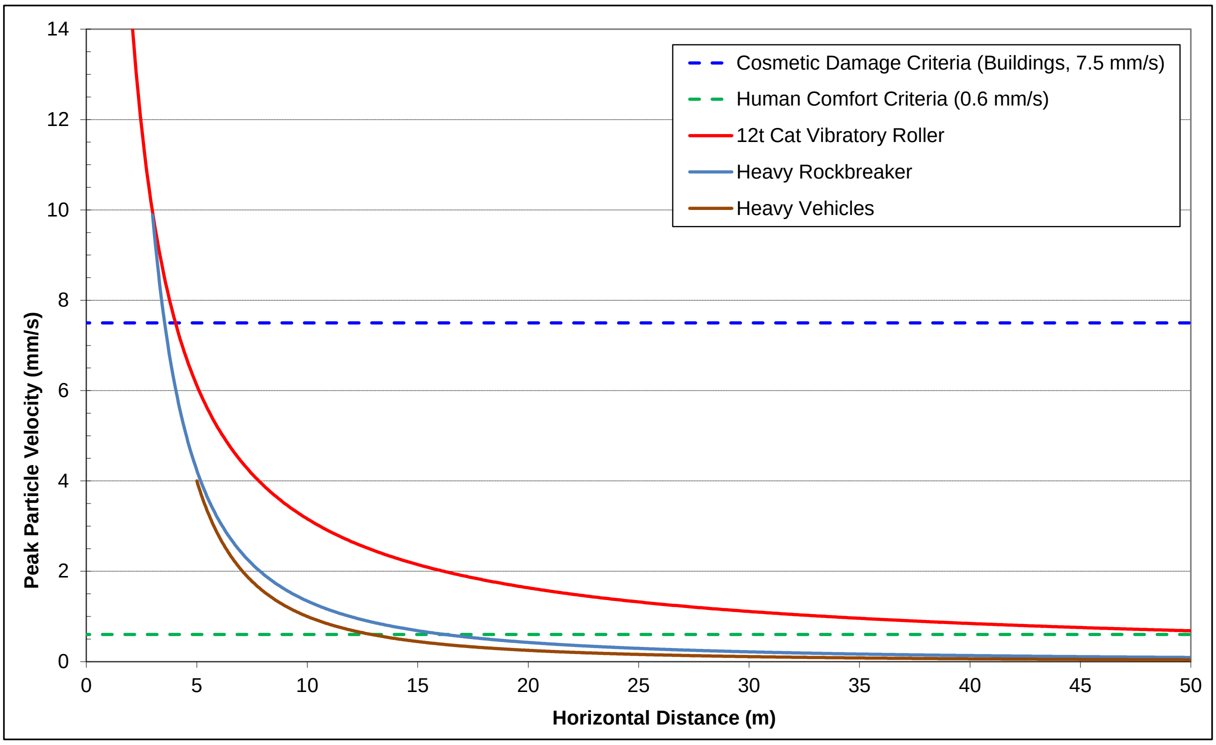
- Rockbreaking
- Compaction with vibratory rollers
- Heavy vehicle movements.

Blasting is not anticipated for the GFD Project.

Heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration levels, typically ranging from 0.01 mm/s to 0.2 mm/s at the footings of buildings located 10 m to 20 m from a roadway. Very large surface irregularities can cause levels up to 5 to 10 times higher. Based on a fairly rough gravel access road, vibration levels of up to 1 mm/s at 10 m from the access road have been assumed.

The typical maximum levels of ground vibration from rockbreaking, vibratory rollers and heavy vehicle movements sourced from SLR Vibration Measurement Database are shown in **Figure 7**.

Figure 7 Maximum ground vibration – rockbreaking, vibratory rollers and heavy vehicles



The distances required to achieve the building damage criterion for the GFD Project is approximately five metres from construction work (excluding blasting). The distance required to achieve the human comfort criterion for sensitive receptors is approximately 20 m for rockbreaking and heavy vehicle movements rough gravel access roads and approximately 50 m for a heavy vibratory roller. Piling associated with facilities construction has been assumed to be undertaken by bored piling, which generates less vibration than the rockbreaker.

SLR has undertaken vibration measurements adjacent to two Santos GLNG employed drill rigs (Rig 103 and Rig 185). At both locations the measured vibration levels (PPV) during air drilling operations were below 0.1 mm/s at the drill lease boundary. There are no anticipated vibration impacts from drilling works.

The potential vibration impacts from construction activities are managed through the implementation of the management plans detailed in **Section 7**.

6.3 Operation noise

Operations will occur up to 24 hours a day and predicted noise level at various distances and the corresponding potential impact distances for various predicted noise levels are presented for both neutral and adverse weather conditions in **Table 14**. The potential impacts from operations activities are managed through the implementation of the management plans detailed in **Section 7**.

Table 14 Predicted noise levels at various distances – operation

Weather conditions	Scenario	Predicted noise level with distance (dBA L_{Aeq})						
		50 m	100 m	250 m	500 m	1,000 m	2,000 m	5,000 m
Neutral	Hub gas compression facility (non-electrified)	83	77	66	57	48	39	25
	Hub gas compression facility (electrified)	77	71	59	50	42	33	19
	Nodal gas compression facility	76	70	58	50	41	31	15
	Water treatment facility	57	51	39	30	22	<15	<15
	Well (non-electrified)	50	44	32	24	15	<15	<15
	Well (electrified/ free-flowing)	36	28	17	<15	<15	<15	<15
	Gas compression facility - flaring	80	74	62	54	45	36	20
	Accommodation camp	64	59	47	39	30	21	<15
Adverse	Hub gas compression facility (non-electrified)	84	78	69	62	53	44	30
	Hub gas compression facility (Electrified)	78	72	62	55	47	39	24
	Nodal gas compression facility	78	72	63	55	46	37	21
	Water treatment facility	58	52	44	36	27	17	<15
	Well (non-electrified)	51	45	36	28	20	<15	<15
	Well (electrified/ free-flowing)	37	28	20	15	<15	<15	<15
	Gas compression facility - flaring	81	75	67	59	51	41	25
	Accommodation camp	64	59	50	42	34	25	<15

Based on the predicted noise emission levels at various distances shown in **Table 14**, the potential impact distances to various noise levels have been presented in **Table 15**.

Table 15 Predicted impact distances for various predicted noise levels – operation

Weather conditions	Scenario	Distance to predicted noise level (m)[1]								
		65 dBA	55 dBA	50 dBA	45 dBA	40 dBA	35 dBA	30 dBA	28 dBA	25 dBA
Neutral	Hub gas compression facility (non-electrified)	300	600	900	1,300	1,900	2,700	3,700	4,100	4,900
	Hub gas compression facility (electrified)	160	350	550	800	1,200	1,700	2,500	2,800	3,400
	Nodal gas compression facility	150	350	500	750	1,100	1,600	2,200	2,500	3,000
	Water treatment facility	<50	70	110	160	250	350	550	650	800
	Well (non-electrified)	<50	50	60	80	140	200	300	350	450
	Well (electrified/ free-flowing)	<50	<50	<50	<50	<50	60	80	100	130
	Gas compression facility - flaring	200	500	700	1,100	1,500	2,200	2,900	3,300	3,800
	Accommodation camp	<50	140	200	300	500	700	1,000	1,200	1,500
Adverse	Hub gas compression facility (non-electrified)	400	900	1,300	1,900	2,700	3,700	4,900	5,500	6,500
	Hub gas compression facility (electrified)	200	500	800	1,200	1,800	2,600	3,600	4,100	4,800
	Nodal gas compression facility	250	500	750	1,200	1,700	2,300	3,200	3,500	4,200
	Water treatment facility	<50	80	130	250	350	550	800	950	1,200
	Well (non-electrified)	<50	50	60	110	180	300	450	550	700
	Well (electrified/ free-flowing)	<50	<50	<50	<50	<50	60	80	110	150
	Gas compression facility - flaring	300	700	1,100	1,600	2,200	3,000	3,900	4,400	5,100
	Accommodation camp	<50	160	250	400	600	900	1,400	1,600	2,000

Note 1: The distances are based on predicted noise levels at 10 m intervals up to 200 m, 50 m intervals up to 1,000 m and 100 m intervals thereafter.

Note: Grey highlighted cells represent distances where further noise management and mitigation measures may be required to achieve noise limits. Further noise management and mitigation measures are discussed in **Section 7**.

6.3.1 Hub gas compression facility operation

Table 14 and **Table 15** show that the hub gas compression facility operation is the most significant operational noise source. The dominant noise sources for the non-electrified hub gas compression facilities are the exhausts for the gas turbines and engines which drive compressors and alternators. The predicted noise emission level for an electrified hub gas compression facility that does not have exhaust noise emissions is 6 dBA less compared to the non-electrified hub gas compression facility.

Table 15 show that for the hub gas compression facility operation, no further noise management and mitigation measures are required where sensitive receptors are at distance greater than the following:

- Non-electrified hub gas compression facility
    - 4,100 m – neutral weather conditions
    - 5,500 m – adverse weather conditions.
- Electrified hub gas compression facility
    - 2,800 m – neutral weather conditions
    - 4,100 m – adverse weather conditions.

6.3.2 Nodal gas compression facility operation

Table 14 and **Table 15** show that the nodal gas compression facilities have slightly lower noise emissions compared to the electrified hub compression facilities. The dominant noise sources are the compressor engines.

Table 15 shows that for the nodal gas compression facility operation, no further noise management and mitigation measures are required where sensitive receptors are at a distance greater than the following:

- 2,500 m – neutral weather conditions
- 3,500 m – adverse weather conditions.

6.3.3 Water treatment facility

Table 14 shows that the noise emission from operating the water treatment facility, which is assumed to be co-located with a gas compression facility, is predicted to be more than 10 dBA below the noise emissions from the individual gas compression facility. The water treatment facility is expected to have a negligible effect on the overall noise emission and distances from the hub and nodal gas compression facilities.

6.3.4 Well operation

Table 15 shows that for the operation of wells, no further noise management and mitigation measures are required where sensitive receptors are at distance greater than the following:

- 100 m (electrified/ free flowing well) to 350 m (non-electrified well) – neutral weather conditions
- 110 m (electrified/ free flowing well) to 550 m (non-electrified well) – adverse weather conditions.

6.3.5 Gas compression facility - flaring

Noise emissions from emergency flaring are expected to increase the overall facility noise emissions by a marginal 2 dBA at a non-electrified hub gas compression facilities and 5 dBA at an electrified hub gas compression facilities.

The emergency flaring events associated with a nodal gas compression facility are expected to emit lower noise emissions compared to the hub gas compression facility. As the normal operation of the nodal gas compression facility emits lower noise levels compared to the hub gas compression facility, a similar marginal increase (i.e. 2 dBA to 5 dBA) of the normal operational noise levels is expected during emergency flaring events.

6.3.6 Accommodation camp

Table 15 shows that for the operation of accommodation camps, no further noise management and mitigation measures are required where sensitive receptors are at a distance greater than the following:

- 1,200 m – neutral weather conditions
- 1,600 m – adverse weather conditions.

6.3.7 Low frequency noise

Similar to the noise predictions for the A-weighted (dBA) noise levels discussed above, the linear unweighted (dBZ) have been predicted to assess potential low frequency impacts. The predicted distance to achieve the internal low frequency criterion of 55 dBZ was shorter compared to the corresponding distance to achieve the overall A-weighted criteria. If the night–time noise criterion of 28 dBA L_{Aeq} is achieved the low frequency criterion will also be achieved.

6.4 Operational vibration

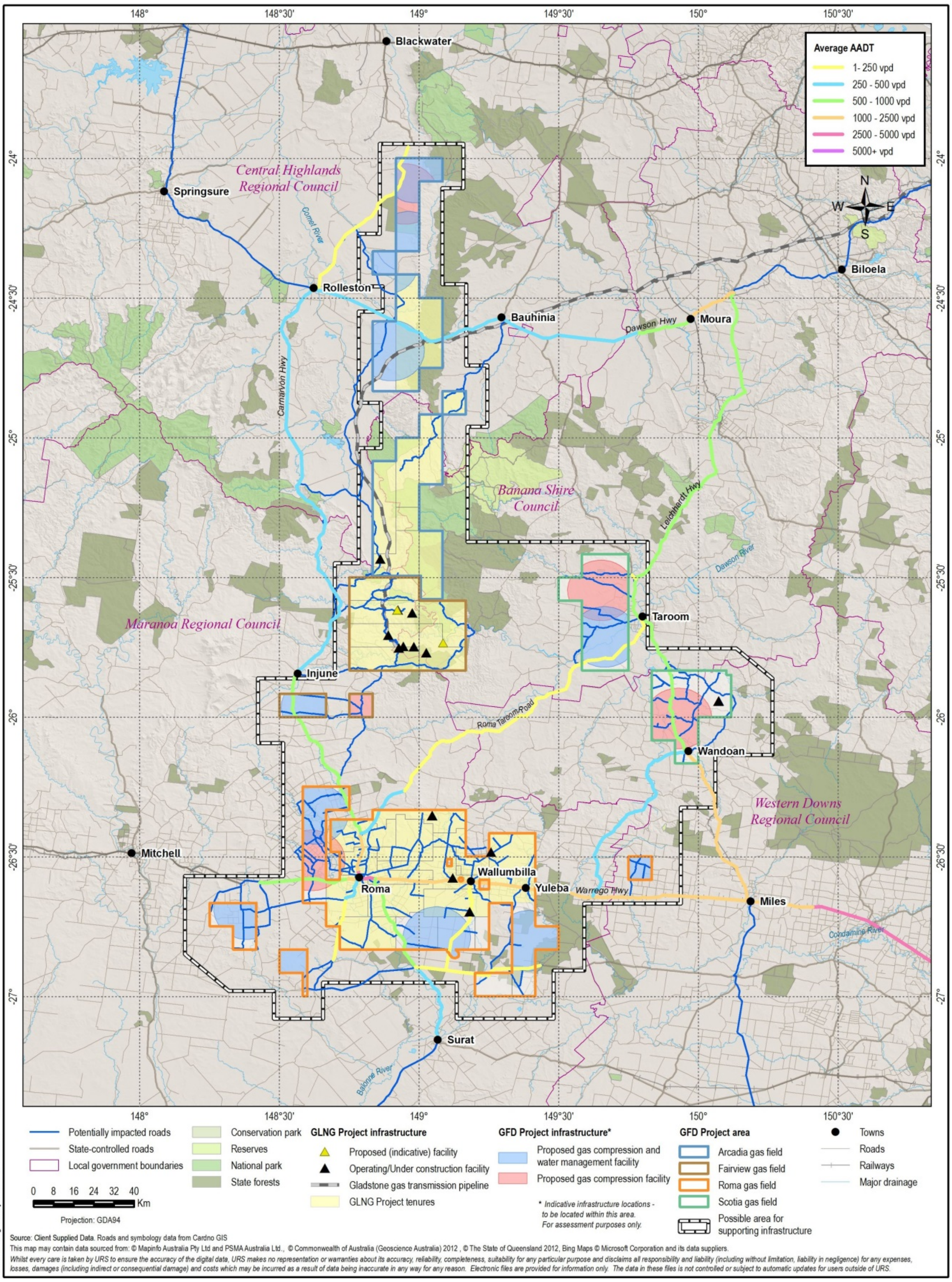
There are no significant vibration generating plant and equipment associated with the operation of the GFD Project that have the potential to cause vibration levels perceivable outside operational work areas. No vibration impacts are anticipated from the operation of the GFD Project.

6.5 Transportation

The GFD Project will extend from the area around Roma to north of Rolleston. The road network providing access to the gas fields is a combination of sealed State-controlled roads and both sealed and un-sealed (gravel) public (Council-controlled) roads.

The State-controlled road network has a large volume of traffic travelling at high speeds ranging from 80 km/h to 110 km/h, whereas the gravel roads providing access to the gas fields have lower traffic volumes and speeds. Potentially impacted roads affected by traffic associated with the GFD Project is shown in **Figure 8**.

Figure 8 Road network



Source: URS, 2014; File number 42627064-g-1074d.mxd

6.5.1 State-controlled roads

A summary of the existing and GFD Project related traffic volumes as provided by Cardno are shown in **Table 16**.

Table 16 Existing and GFD Project related traffic volumes on State-controlled roads

Road	Year with estimated peak GFD Project traffic volumes	Existing traffic volumes[1]		GFD Project traffic volumes[2]	
		AADT	% heavy vehicles	Peak daily Traffic	% heavy vehicles
Warrego Highway	2022	1,193 – 16,419	14 - 32	115 - 688	81 - 86
Carnarvon Highway	2024	564 – 3,838	28 - 50	196 – 1,530	70 - 86
Leichhardt Highway	2024	941 – 1,617	36 - 50	227 – 1,082	89 - 98
Dawson Highway	2027	390 – 3,184	14 - 43	184 – 283	72 - 98
Fitzroy Development Road	2024	51 – 158	18 - 40	149	93
Roma Condamine Road	2030	118 – 347	25 - 27	140	87
Blackwater Rolleston Road	2036	182 – 189	29 - 63	154 – 301	65 - 68
Wallumbilla South Road	2022	44 – 326	21 - 28	78 – 286	94 - 95
Roma Southern Road	2023	158 – 627	17 - 32	121	78
Jackson-Wandoan Road	2024	359 – 360	27 - 28	442	65
Roma Taroom Road	2026	187 – 659	22 - 47	11 – 168	2 - 90

Note 1: The existing annual average daily traffic (AADT) numbers above are based on existing (2011) traffic volumes and the percent of heavy vehicle data sourced from TMR and predicted future traffic volumes based on 3% annual traffic growth. Traffic for both directions.

Note 2: Traffic for both directions.

Predicted road traffic noise levels for the existing traffic and existing plus GFD Project traffic for the year with the peak GFD Project traffic on each road section is presented in **Table 17**.

The speed on State-controlled roads in **Table 17** has been assumed to be 100 km/h for the predictions.

Table 17 Predicted road traffic noise on State-controlled roads

Road	Year with estimated peak GFD Project traffic volumes	Existing road traffic noise (dBA $L_{A10(18hour)}$)[1]				Existing and Peak GFD Project Road Traffic Noise (dBA $L_{A10(18hour)}$)[1]				Incremental change in existing noise (dBA)
		Distance from road edge				Distance from road edge				
		25 m	**50 m**	**75 m**	**100 m**	**25 m**	**50 m**	**75 m**	**100 m**	
Warrego Highway (high traffic sections)	2022	67 - 71	64 - 68	62 - 66	61 - 65	69 - 72	66 - 69	64 - 67	63 - 66	0.6 - 1.8
Warrego Highway (low traffic sections)	2022	61 - 68	58 - 65	56 - 63	55 - 62	62 - 68	59 - 65	57 - 63	56 - 62	0.4 - 4
Carnarvon Highway	2024	59 - 66	56 - 63	54 - 61	53 - 60	59 - 68	56 - 65	54 - 63	53 - 62	0 - 7
Leichhardt Highway	2024	61 - 63	58 - 60	57 - 59	55 - 57	62 - 66	59 - 63	57 - 61	56 - 60	0 - 4
Dawson Highway	2027	57 - 64	54 - 61	53 - 59	51 - 58	60 - 65	57 - 62	55 - 60	54 - 59	1 - 4
Fitzroy Development Road	2024	47 - 53	44 - 50	42 - 48	41 - 47	47 - 58	44 - 55	42 - 53	41 - 52	0 - 4
Roma Condamine Road	2030	51 - 56	48 - 52	46 - 51	45 - 49	51 - 57	48 - 54	46 - 52	45 - 51	0 - 4
Blackwater Rolleston Road	2036	53 - 55	50 - 52	48 - 50	47 - 49	55 - 59	52 - 56	50 - 54	49 - 53	0 - 6
Wallumbilla South Road	2022	46 - 55	43 - 52	41 - 51	40 - 49	54 - 60	51 - 57	49 - 55	48 - 54	5 - 8
Roma Southern Road	2023	53 - 57	49 - 54	48 - 52	46 - 51	56 - 59	53 - 56	52 - 54	50 - 53	2 - 4
Jackson-Wandoan Road	2024	56 - 56	53 - 53	51 - 51	50 - 50	61 - 61	58 - 58	56 - 56	55 - 55	5 - 5
Roma Taroom Road	2026	52 - 60	49 - 57	48 - 55	46 - 54	55 - 60	52 - 57	50 - 55	49 - 54	0 - 5

Note 1: Traffic speed on State-controlled roads assumed to be 100 km/h.

The road traffic noise predictions in **Table 17** show that there are sections on the Warrego Highway that have predicted road traffic noise levels exceeding 68 dBA $L_{A10(18hour)}$ at up to 50 m from the road. However, the incremental change in road traffic noise levels due to the contribution of the GFD Project traffic is less than 2 dBA and hence the road traffic noise criteria is achieved.

For other State-controlled roads the 68 dBA $L_{A10(18hour)}$ criterion is achieved. However, there are road sections with lower existing traffic volumes where the GFD Project traffic will significantly contribute to the cumulative road traffic noise emissions.

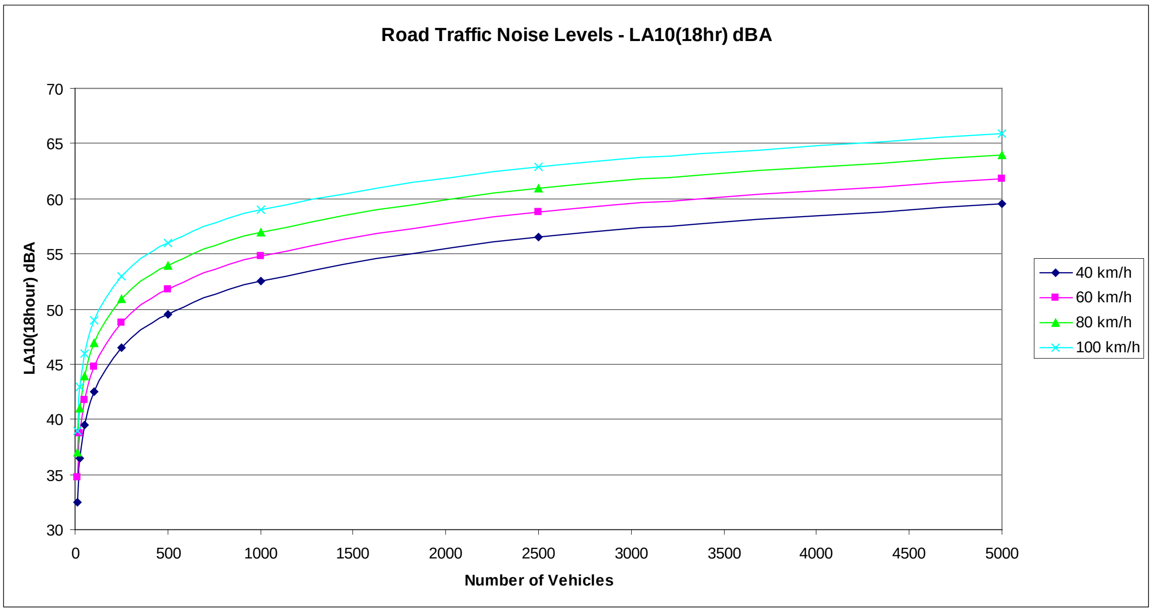
6.5.2 Public roads and access roads

GFD Project-related traffic movements associated with well construction and operation and associated with gas compression facilities construction and operation is outlined in Appendix 12: Traffic and Transport (Cardno, 2014).

In order to assess the likely compliance with the road traffic noise criterion, the overall $L_{A10(18hour)}$ road traffic noise level from vehicles (associated with the GFD Project) travelling on public roads was estimated.

Figure 9 shows the predicted $L_{A10(18hour)}$ road traffic noise level at a distance of 25 m from the road edge for a range of traffic volumes and speeds.

Figure 9 Relationship between road traffic noise level, traffic volume and vehicle speed



Note: Road traffic noise levels are predicted at an off-set distance from the road pavement edge of 25m.

Figure 9 shows that a public road with a speed limit of 80 km/h could carry up to 4,000 light vehicles per day and achieve the $L_{A10(18hour)}$ road traffic noise criterion of 63 dBA at a distance of 25 m from the road edge. If conservatively assuming 50% heavy vehicles, the number of allowed vehicle movements is reduced to 1,000 vehicles per day at 80 km/h.

It is noted that the road traffic noise predictions in **Figure 9** are based on a Dense Graded Asphalt (DGA) road surface (0 dBA correction). It is likely that some new roads would be required throughout the GFD Project area to service the wells and gas compression facilities and these would likely be either dirt roads or a chip seal road surface. In these instances, the predicted road traffic noise levels would be typically 5-7 dBA higher than for a DGA road surface, resulting in approximately a 1,000 light vehicle movements per day at 80 km/h.

Assuming 50% heavy vehicles, approximately a 250 vehicle movements per day at 80 km/h would be allowed on public roads with dirt or a chip seal road surface, noting that on access roads the speed limits is likely to be less than 80 km/h.

6.5.3 Predicted incremental change in road traffic noise levels

In addition to the discussion above with regards to absolute traffic volumes on public roads achieving the noise criterion of 63 dBA $L_{A10(18hour)}$, the following section gives a discussion on the likely change in $L_{A10(18hour)}$ road traffic noise levels due to the additional vehicle movements associated with the GFD Project.

In order to assess the likely change in $L_{A10(18hour)}$ road traffic noise levels due to the additional vehicle movements associated with the GFD Project, the existing traffic volumes on the subject road are required.

Data relating to the existing traffic and the GFD Project related traffic volumes on public roads within the GFD Project area was not available at the time of reporting. Therefore it is appropriate to consider the resultant change in $L_{A10(18hour)}$ road traffic noise levels as a function of the percentage increase in traffic volume (as a result of the GFD Project) on the subject road.

Assuming that the proportion of heavy vehicles, traffic speed and road surface remain constant, the relationship between increases in traffic volume on a roadway and the resulting increase in $L_{A10(18hour)}$ traffic noise emission can be determined and is summarised in **Table 18**.

Figure 10 shows the relationship between existing traffic volumes and the increase in vehicle movements in terms of the $L_{A10(18hour)}$ noise level. This change assumes that the number of heavy vehicles, traffic speed and road surface remains constant.

Table 18 Relationship between traffic volumes changes and $L_{A10(18hour)}$ noise emissions

Increase/decrease in AADT traffic (%)	Resultant change in $L_{A10(18hour)}$ noise emission (dBA)
10	0.4
25	1.0
50	1.8
75	2.4
100	3.0

Figure 10 Change in road traffic noise levels with additional traffic

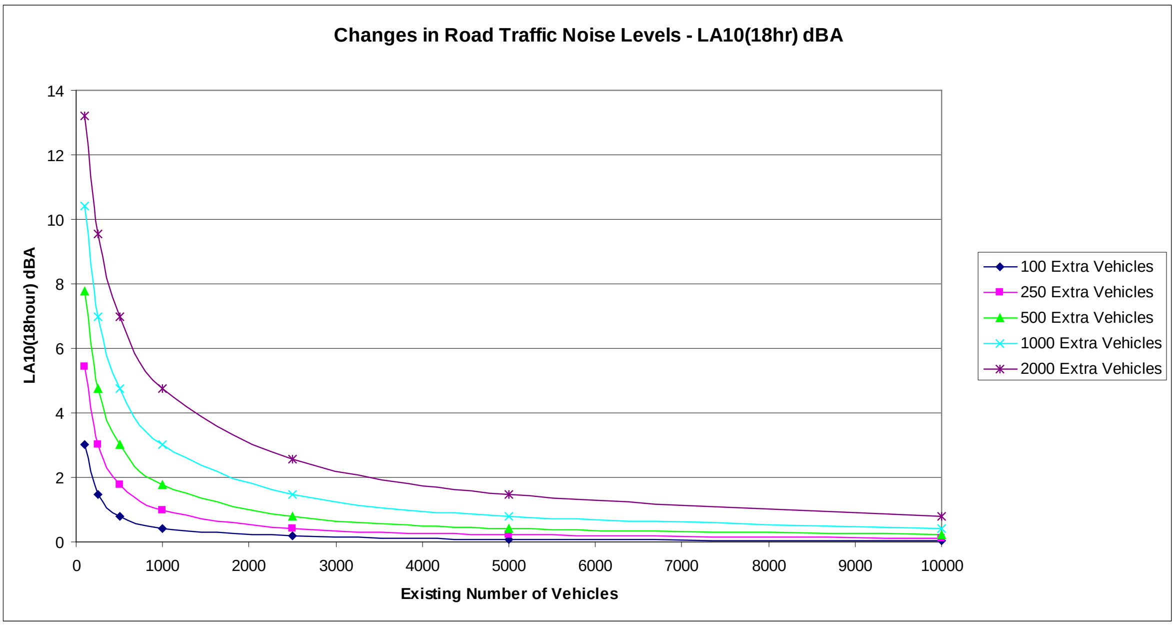


Table 18 shows that an increase in traffic volumes of approximately 50% would result in less than 2 dBA change in noise level and achieve the incremental change noise criterion of less than 2 dBA. This equates to approximately 1,000 GFD Project related traffic movements on a public road with background traffic of 2,000 vehicle movements as illustrated in **Figure 10**.

Similar to **Table 18**, **Table 19** shows the relationship between changes to percentage of heavy vehicle movements and $L_{A10(18hour)}$ noise emissions. This change assumes that the traffic volumes, traffic speed and road surface remains constant.

Table 19 Relationship between changes to percentage heavy vehicle movements and $L_{A10(18hour)}$ noise emissions

	Change to noise emission (dBA) vs future %HV								
Existing %HV	**5%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**
5%	-	0.9	2.3	3.4	4.3	5.0	5.6	6.1	6.6
10%	-0.9	-	1.4	2.5	3.3	4.0	4.7	5.2	5.7
20%	-2.3	-1.4	-	1.1	1.9	2.6	3.2	3.8	4.3
30%	-3.4	-2.5	-1.1	-	0.9	1.6	2.2	2.7	3.2
40%	-4.3	-3.3	-1.9	-0.9	-	0.7	1.3	1.9	2.3
50%	-5.0	-4.0	-2.6	-1.6	-0.7	-	0.6	1.1	1.6

The potential noise and vibration impacts from transportation are managed through the implementation of the management plans detailed in **Section 7**. Further detail is covered in the traffic and transport impact assessment prepared by Cardno for the GFD Project EIS (Cardno, 2013).

6.6 Cumulative impacts

6.6.1 Between GFD Project and other projects

To assess the potential cumulative noise impacts from the GFD Project and other projects, the cumulative noise levels at various distances between facilities have been predicted, assuming a sensitive receptor is located in the middle.

In predicting the cumulative noise levels, a conservative assumption that the other project facility is of similar size and noise emission as the largest GFD Project facility (i.e. non-electrified hub gas compression facility) has been made. The predicted cumulative noise level at a sensitive receptor located in the middle between a GFD Project facility and another project's facility are shown in **Table 20**.

Table 20 Predicted cumulative noise levels

Weather conditions	Scenario	Predicted cumulative noise level at distance (dBA L_{Aeq})				
		500 m	**1,000 m**	**2,000 m**	**4,000 m**	**10,000 m**
Neutral	Hub gas compression facility (non-electrified)	69	60	51	42	28
	Hub gas compression facility (electrified)	66	58	49	40	26
	Nodal gas compression facility	66	58	49	40	25
	Accommodation camp	66	57	48	39	25
Adverse	Hub gas compression facility (non-electrified)	72	65	56	47	33
	Hub gas compression facility (electrified)	70	62	54	45	31
	Nodal gas compression facility	70	62	54	45	30
	Accommodation camp	69	62	53	44	30

Based on the predicted cumulative noise levels in **Table 20**, distances between GFD Project facilities and other facilities where no cumulative noise impacts are predicted (i.e. the night–time noise criterion of 28 dBA L_{Aeq} is achieved), have been calculated and is presented in **Table 21**.

Table 21 Predicted cumulative impact distance

Weather conditions	Scenario	Cumulative impact distance (m)[1]
Neutral	Hub gas compression facility (non-electrified)	9,800
	Hub gas compression facility (electrified)	8,300
	Nodal gas compression facility	7,900
	Accommodation camp	6,400
Adverse	Hub gas compression facility (non-electrified)	13,000
	Hub gas compression facility (electrified)	11,300
	Nodal gas compression facility	10,700
	Accommodation camp	8,500

Note 1: The distances to where no cumulative noise impacts are predicted are based on an adjacent project of similar noise emissions as the largest GFD Project facility (i.e. a non-electrified hub gas compression facility).

Table 21 shows that cumulative noise levels may need to be considered if a GFD Project facility and another facility are located within the following distances:

- 9,800 m – neutral weather conditions
- 13,000 m – adverse weather conditions.

Where a GFD Project facility and another facility are located within the predicted cumulative impact distances further noise management and mitigation measures may be required, as outlined in **Section 7**.

6.6.2 Multiple well leases

To assess the potential cumulative noise levels from gas fields with multiple well leases, the following two modelling scenarios have been considered:

- High density – 600 m between well leases.
  - Electrified or free flowing wells
- Low density – 1 km between well leases.
  - Non-electrified wells
  - Electrified or free flowing wells.

The SWL for non-electrified and electrified wells are specified in **Appendix H**. It should also be noted that where wells are located within close proximity to a major facility, power is most likely to be provided from the facility to the well. The predicted noise contours for the different well configurations are presented in **Figure 11**.

Figure 11 Production well configurations in high density and low density gas fields – cumulative noise levels

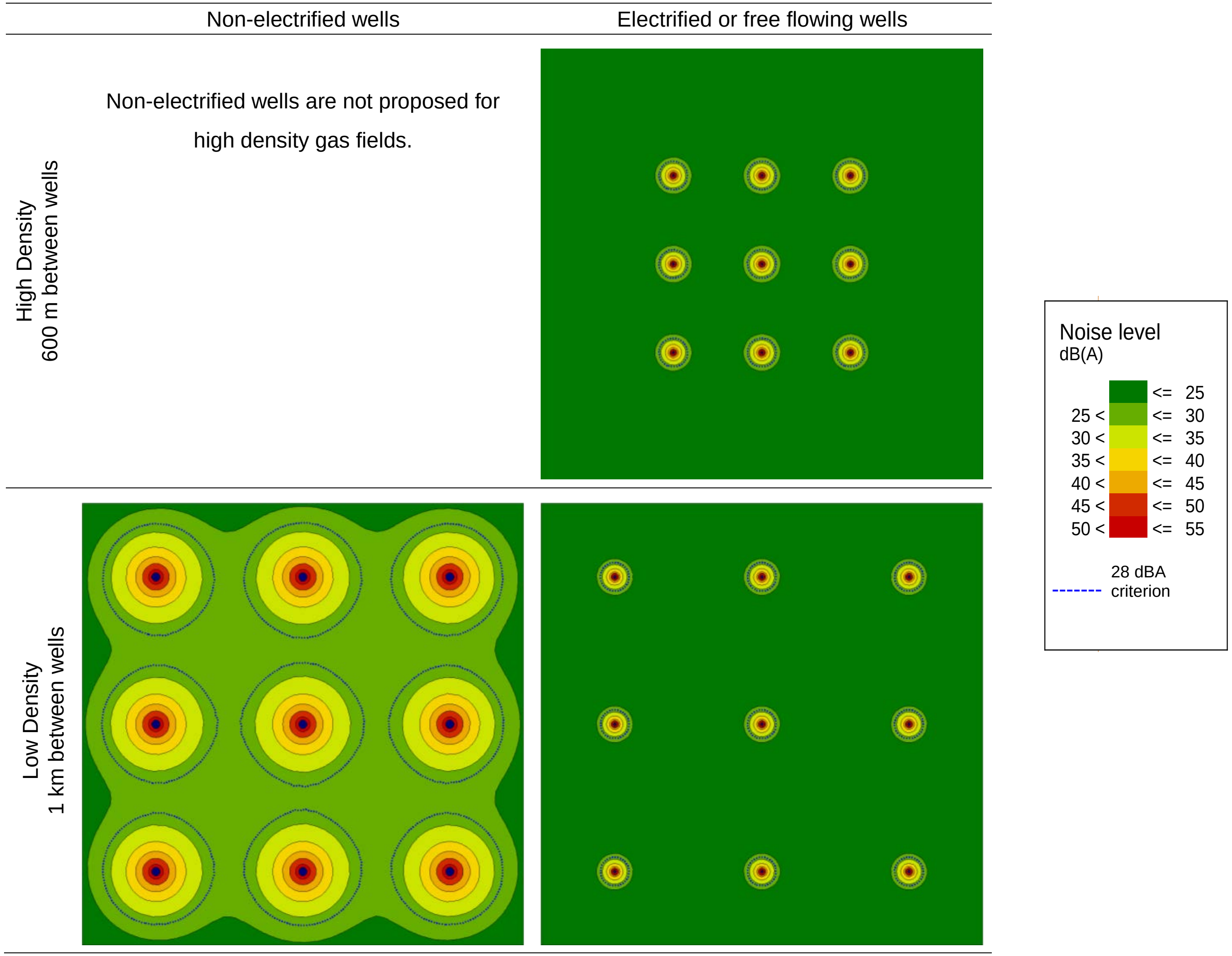


Figure 11 shows that there is a marginal cumulative build-up of the noise levels for the non-electrified wells in the low density well configuration. Effective placement of wells (in accordance with the Constraints protocol) will help mitigate potential impacts on sensitive receptors.

For the electrified and free flowing well configurations, **Figure 11** shows that there is no cumulative build-up of the noise levels for neither high density nor low density well configuration.

6.6.3 Well leases adjacent to gas compression facilities

Predicted cumulative noise levels around well leases located adjacent to a gas compression facility results in increased impact distance to where no further noise management and mitigation measures are required. No further noise management and mitigation measures are required for wells located adjacent to a hub or nodal gas compression facility where sensitive receptors are at a distance greater than the following:

- 130 m (electrified or free flowing well) to 450 m (non-electrified well), for a well lease located between 4,000 m and 5,000 m from a non-electrified hub gas compression facility
- 130 m (electrified or free flowing well) to 450 m (non-electrified well), for a well lease located between 2,500 m and 3,000 m from a nodal or electrified hub gas compression facility.

6.6.4 Co-location of water treatment facility and gas compression facility

The noise emissions from the water treatment facility, which will always be co-located with a hub or nodal gas compression facility are more than 10 dBA less than the hub or nodal gas compression facility noise emissions, and will therefore have negligible increase to the overall cumulative noise emission levels.

6.7 Impacts on fauna

For construction of facilities and infrastructure, the predicted noise emissions shows that distances of approximately 100 m to 150 m are required to achieve the noise criterion of 65 dBA L_{Aeq} to ensure no impacts on fauna. For drilling during adverse weather conditions, impacts may occur up to 250 m, which extends up to 450 m with blooie line operation.

For operation, the predicted noise emissions shows that distance required to achieve the noise criterion of 65 dBA L_{Aeq} to ensure no impacts on fauna is up to 300 m under neutral weather conditions, increasing up to 400 m under adverse weather conditions for a non-electrified hub gas compression facility.

The GFD Project is expected to have insignificant vibration emissions (**Sections 6.2**and **6.4**) and as there is very little documented evidence of vibration impacts on fauna the potential impacts from the GFD Project on fauna are expected to be minimal.

The potential noise and vibration impacts on fauna are managed through the implementation of the management plans detailed in **Section 7**.

6.8 Discussion of factors affecting noise propagation

As previously stated, the predicted noise levels and potential impact distances documented in **Table 12** to **Table 15** includes weather effects as specified in **Table 10**, and they assume propagation over flat, soft ground (i.e. open grassland) to a typical sensitive receptor. The following sections discuss potential changes to predicted noise levels based on the following:

- Topographical effects
- Vegetation attenuation.

6.8.1 Topographical effects

Local topography can dramatically affect the propagation of noise, especially if the construction works are conducted through areas with steep terrain (i.e. portions of the Fairview and Acadia gas fields). The extent of change in noise levels due to topographical effects is dependent on the level of shielding provided (which would be very much locality specific). The actual degree of noise attenuation due to topographical shielding is a function of the frequency spectrum of the noise and the length of the diffracted noise path compared to the direct noise path.

Noise attenuation due to topographical shielding typically ranges from 5 dBA if line-of-sight between the noise source and receptor location is just obscured, and up to approximately 15 dBA where the topography provides optimal blocking of the sound transmission path.

During adverse weather conditions, noise attenuation due to topographical shielding would be less than that expected during neutral weather conditions.

6.8.2 Vegetation attenuation

Dense forest increases the amount of sound absorption along the noise propagation path. The increased sound absorption of typical forest vegetation is estimated to be between 0.05 to 0.1 dBA per metre of propagation distance up to a maximum attenuation of approximately 15 dBA compared to soft ground at distances of more than 300 m.

7 MANAGEMENT AND MITIGATION MEASURES

Based on the assessment of constraints and potential noise impacts, it has been identified that where construction (excluding drilling) associated with the GFD Project is undertaken within 600 m to 1,200 m of sensitive receptors, there is a predicted potential for noise impacts. For drilling construction undertaken within 2,000 m to 4,400 m of sensitive receptors, there is a predicted potential for noise impacts.

The assessment of potential noise impacts from the GFD Project has determined that there is a predicted potential for noise impacts within 5,500 m from the largest (i.e. noisiest) facility under adverse weather conditions.

The recommendations in this section are provided to manage and, where practicable, mitigate potential noise emissions and should be considered during the planning and scheduling of GFD Project activities to manage noise emission levels at potential sensitive receptors.

A summary of the GFD Project commitments to manage and minimise potential noise impacts is listed in **Table 22**. The following sections give further details of the procedures outlined within the existing Santos GLNG management systems and plans in place to manage noise.

Table 22 Mitigation measures and commitments

Management plan	Mitigation measures
GFD Project Environmental protocol for constraints planning and field development (the Constraints protocol)	The Constraints protocol applies to all gas field related activities. The scope of the Constraints protocol is to: • Enable Santos GLNG to comply with all relevant State and Federal statutory approvals and legislation • Support Santos GLNG's environmental policies and the General Environmental Duty (GED) as outlined in the EP Act • Promote the avoidance, minimisation, mitigation and management of direct and indirect adverse environmental impacts associated with land disturbances • Minimise cumulative impacts on environmental values. The Constraints protocol provides a framework to guide placement of infrastructure and adopts the following management principles: • Avoidance — avoiding direct and indirect impacts • Minimisation — minimise potential impacts • Mitigation — implement mitigation and management measures • Remediation and rehabilitation — actively remediate and rehabilitate impacted areas • Off-set — offset residual adverse impacts in accordance with regulatory requirements. The Constraints protocol enables the systematic identification and assessment of environmental values and the application of development constraints to effectively avoid and / or manage environmental impacts. Noise is identified as a planning constraint within the Constraints protocol. Noise constraints will be identified and managed in accordance with the noise management plan.
Noise management plan (NMP)	The NMP identifies potential noise impacts from Santos GLNG activities and provides a strategy, methods and controls to: • Avoid — plan the activity and engage with potentially affected stakeholders • Minimise — implement noise mitigation measures to minimise noise impacts • Manage — conduct monitoring, review mitigation methods and ensure compliance with Santos GLNG procedures. Noise will be managed in accordance with the NMP, which details: • Risk / constraint analysis methods to be undertaken prior to new operation or installation of new equipment that has the potential to create noise nuisance • Procedures and methods to undertake noise assessments to determine compliance with the stipulated noise limits • Procedures for handling noise complaints, and procedures for community liaison and consultation • Details of petroleum activities and measured and / or predicted noise levels of noise sources associated with those activities • Reasonable and practicable control or abatement measures to ensure compliance with the established noise limits • Mediation processes to be used in the event that noise complaints are not able to be resolved. The NMP provides the following: • Overview of noise management strategies • Description of relevant roles and responsibilities • Noise monitoring procedures including a noise measurement form specifying relevant noise parameter and information that as a minimum should be documented when undertaking compliance noise monitoring • Summary of the noise-related environmental authority conditions • Overview of potential non-compliance issues and methods for re-establishing compliance, as practicable

Management plan	Mitigation measures
	• Community liaison and consultation procedures • Complaint management procedures. The NMP also outlines a process for assessing and managing noise issues in the following manner: • Identifying noise producing activity • Identifying the duration of the activity from short-term to long-term • Identifying the time periods that the activity will be carried out and defining background noise levels • Predicting the noise levels resulting from the activity at sensitive receptor(s) • Assessing the risk for the activity and following relevant noise protocols accordingly. The NMP also sets out the noise control hierarchy adopted by Santos GLNG: • Elimination of the noise source (locate the facility so there are no sensitive receptors within the determined impact distances in **Table 13** and **Table 15**). • Substitution with quieter equipment/process (at the planning stage investigate alternative quieter equipment) • Engineering noise controls at the source (e.g. upgraded exhaust silencers, enclosures). The noise emissions from the treated plant could typically be reduced by 10 dBA to 20 dBA • Treatment of the noise propagation path (e.g. noise barriers, orientation and location of plant items). The noise emission at sensitive receptor could typically be reduced by 5 dBA to 15 dBA • Noise mitigation measures at the sensitive receptor. Appropriate measures to be negotiated through community liaison controls.
Blast management plan, if required	Blasting is not anticipated for the GFD Project; however, a Blast management plan will be developed prior to blasting activity occurring in accordance with Australian Standard 2187 *Explosives - Storage, Transport and Use*.
Draft EM plan	The Draft EM plan provides the environmental monitoring and assessment approach Santos GLNG implements across its development activities. Monitoring and reporting requirements are outlined within the NMP and the Draft EM Plan, which include objectives to be achieved to protect the noise environment. Noise monitoring and compliance testing will be conducted by a suitably qualified person in accordance with the prescribed standards in the Noise Measurement Manual (EHP, 2013) and the *AS1055.1-1997 Acoustics - Description and Measurement of environmental noise - Part 1: General Procedures*.

7.1 Monitoring, recording and corrective action

Noise monitoring, recording and corrective action will be specified under the environmental authority. Should the administering authority advise Santos GLNG of a complaint alleging noise nuisance, the complaint will be investigated as soon as practicable. Investigations in accordance with the environmental authority conditions will usually involve monitoring and actions proposed to resolve the complaint.

8 CONCLUSIONS

SLR has undertaken an assessment of the potential noise and vibration impacts associated with the construction and operation of the GFD Project. Noise and vibration emissions have been assessed with reference to the ToR for the GFD Project EIS.

The existing acoustic environment for the GFD Project area have been sourced from noise monitoring data collected for previous studies (2009 EIS and APLNG EIS). These studies showed that the prevailing acoustic environment has low background noise levels characteristic of rural environments with minimal noise influences. At locations away from local and main roads, the monitored background noise levels were below the deemed background noise levels according to the EHP guidelines, *Prescribing Noise Conditions for Petroleum and Gas Activities* (2012). Therefore, the GFD Project noise criteria (see **Section 5.1**) were determined based on the deemed background noise levels.

8.1 Noise

The noise impact assessment has predicted noise emission levels at various distances from the assessed construction and operations scenarios. Depending on the future locations of major facilities and infrastructure associated with the GFD Project, further management and mitigation measures may be required if sensitive receptors are identified within the determined impact distances in **Table 13** for construction and **Table 15** for operation.

If sensitive receptors are identified within the specified impact distances of major facilities (such as compressor facilities), more detailed modelling would be performed to enable site specific factors such as the surrounding topography and land use to be accounted for in the modelling and investigate if further noise management and/or mitigation measures are required. Noise management and mitigation measures that should be considered are outlined in **Section 7**.

8.2 Cumulative impacts

Cumulative noise levels may need to be considered if a GFD Project facility and another facility are located within 13,000 m of each other for adverse weather conditions.

The cumulative noise assessment of multiple well leases showed a marginal cumulative noise build-up within the low density well configuration for non-electrified wells. High density gas fields with electrified or free flowing wells do not show a cumulative build-up of the predicted noise levels.

Effective placement of wells (in accordance with the Constraints protocol) will help mitigate potential impacts on sensitive receptors.

8.3 Impacts on fauna

For construction of major facilities and infrastructure, the predicted noise emissions shows distances of approximately 100 m to 150 m are required to achieve the noise criterion of 65 dBA L_{Aeq} to ensure no impacts on fauna. For drilling, potential impacts may occur up to a distance of 250 m under adverse weather conditions and with blooie line operation up to 450 m under adverse weather conditions.

For operations the predicted noise emissions shows that distance required to achieve the noise criterion of 65 dBA L_{Aeq} for protecting fauna is up to 300 m under neutral weather conditions, increasing up to 400 m under adverse weather conditions for a non-electrified hub gas compression facility.

8.4 Vibration

The predicted vibration levels in **Section 6.2** showed that the distances required to achieve the vibration criteria were approximately 5 m for building damage and up to 50 m for human annoyance. These are significantly shorter compared to those required to achieve the noise criteria and no impacts are anticipated from vibrations associated with the construction of the GFD Project.

There are no significant vibration generating equipment and plant associated with the operation of the GFD Project and no impacts are anticipated.

8.5 Transportation

There are no predicted noise impacts associated with GFD Project related vehicle movements on State-controlled roads.

A public road with a speed limit of 80 km/h could carry up to 4,000 light vehicles per day and achieve the $L_{A10(18hour)}$ road traffic noise criterion of 63 dBA at a distance of 25 m from the road edge. If conservatively assuming 50% heavy vehicles, the number of allowed vehicle movements is reduced to 1,000 vehicles per day at 80 km/h. For public roads or access roads with dirt or chip seal road surface, the number of allowed vehicle movements is reduced further to approximately 250 vehicle movements per day at 80 km/h. However, it is noteworthy that on access roads the speed limits is likely to be less than 80 km/h and distance to sensitive receptors likely to be greater than 25 m.

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Legislation

Environmental Protection Act 1994 (EP Act)

Environmental Protection (Noise) Policy 2008 (EPP Noise)

Environmental Protection Regulation 2008

1 Sound Level or Noise Level

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

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

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

2 'A' Weighted Sound Pressure Level

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

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

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

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

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

3 Sound Power Level

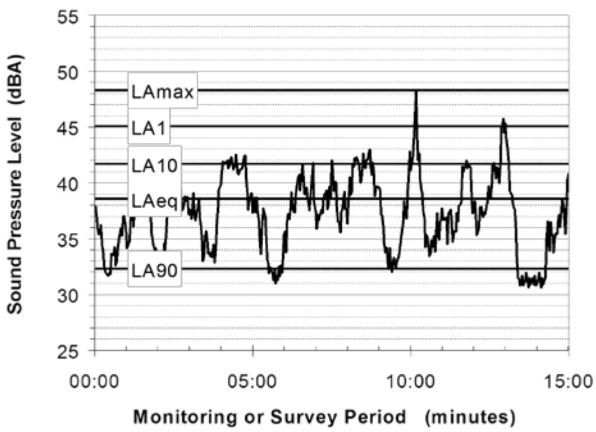
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

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

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

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

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

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

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

5 Tonality

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

6 Impulsiveness

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

7 Frequency Analysis

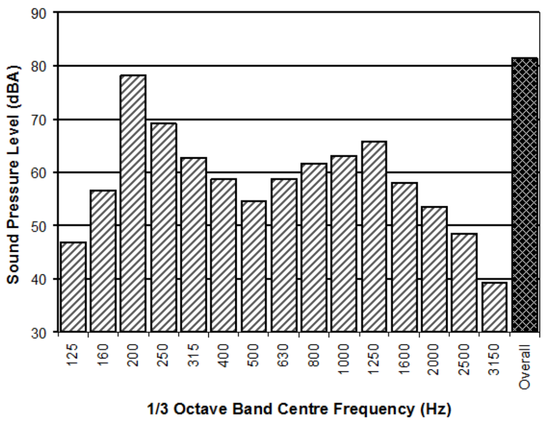
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

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

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

9 Human Perception of Vibration

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

10 Over-Pressure

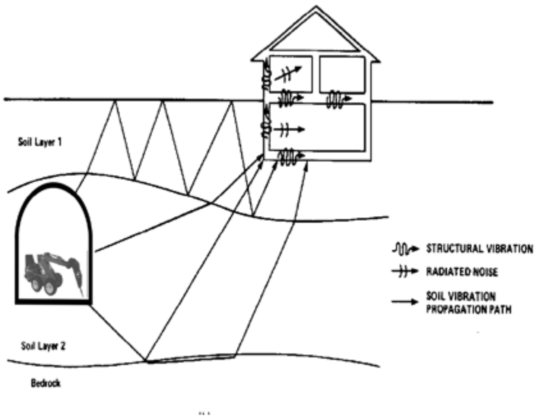
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

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

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

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



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	**Proponent**	**Location**	**Description**	**EIS current status**	**Proposed construction dates**	**Estimated construction jobs**	**Estimated operational jobs**	**Lifespan**	**Relationship to GFD Project**	**Project selection criteria**
Australia Pacific LNG (APLNG)	Origin Energy and Conoco Phillips	Gas fields: Walloons gas fields, stretching from Injune to Millmerran. Pipeline: from gas fields to Gladstone. LNG plant and export terminal: Curtis Island, near Gladstone.	Integrated LNG project. Development of ~10,000 CSG wells over ~5,700 km^2. 450 km gas transmission pipeline. LNG plant and export facility (4 trains with a total capacity of up to 18 Mtpa of LNG)	CG approved Nov 2010	Gas fields: 2010 to 2027 Pipeline: mid-2012 to late-2013. LNG facility: 2011 to 2014	Gas fields: 2,100 Pipeline: 800 LNG facility: 2,100	Gas fields: 700 Pipeline: 20 LNG facility: 100 for 1 train and 75 for each additional train.	30 years	APLNG tenures lay north-west to south-east within 50 km buffer area. Gas fields development periods will overlap.	b)
Arcturus Coal Mine Project	Springsure Creek Coal	~40 km south of Emerald and 60km south-west of Blackwater	Open cut and underground mine and associated infrastructure.	EIS in preparation for submission to EHP	Unknown	300	150	30 years	Located ~50 km west of Arcadia gas field.	a)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	**Proponent**	**Location**	**Description**	**EIS current status**	**Proposed construction dates**	**Estimated construction jobs**	**Estimated operational jobs**	**Lifespan**	**Relationship to GFD Project**	**Project selection criteria**
Blackwater to Emerald Powerline Replacement	Ergon Energy	Preferred 76km route identified between the Blackwater the Emerald.	Upgrade the existing aged powerline from Blackwater to Emerald to 66kV or 132kV dual circuit concrete pole line.	Draft design underway	2014	Unknown	Unknown	30-40 years	Northwest of Arcadia gas field.	c)
Blythedale, Fairview and Fairview South Substations Project	Powerlink	Three locations in area between Wandoan and Injune	Three 132kV substations are proposed to supply future gas compression facilities at Santos GLNG's Roma and Fairview gas fields.	EIS completed in July 2013, and is now released for public comment	2014	Unknown	Unknown	40-50 years	Located near and will supply electricity to facilities within Roma and Fairview gas fields.	c)
Bowen Gas Project	Arrow Energy	Extends from Blackwater north to near Glenden	CSG project. 6,625 CSG production wells and associated infrastructure over ~8,000 km^2	EHP issued public notification of EIS	Commence construction of facilities 2015, initial well drilling commencing 2016, and commence production 2017.	1,540	597	40 years	ATP 1025 is located ~40 km north of Arcadia gas field. Gas field development period will overlap.	a)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	Proponent	Location	Description	EIS current status	Proposed construction dates	Estimated construction jobs	Estimated operational jobs	Lifespan	Relationship to GFD Project	Project selection criteria
Bundi Coal Project	Metro Coal	~20 km south-west of Wandoan	Underground coal mine and associated infrastructure. 5 Mt/y of product coal.	EIS in preparation for submission to EHP	Commence construction 2013, with operations to commence 2015.	300	150	20 years	Located ~20 km south of Scotia gas field.	a)
Dingo West Coal Mine	Dingo West Coal	~6 km west of Dingo and ~120 km east of Emerald	Open cut coal mine. 1 Mt/y of product coal	EIS in preparation for submission to EHP	Unknown	220	120	30 years	Located ~45 km north-east of Arcadia gas field.	a)
Elimatta Project	Taroom Coal	~45 km south-west of Taroom and 380 km north-west of Brisbane	Open cut coal mine. 5 Mt/y product coal	EHP issued public notification of EIS	Commence construction mid-2013 to mid-2015	500	300	40 years	Located ~25 km west of Scotia and ~25 km south of Scotia gas field.	a)

Project	Proponent	Location	Description	EIS current status	Proposed construction dates	Estimated construction jobs	Estimated operational jobs	Lifespan	Relationship to GFD Project	Project selection criteria
Eurombah to Fairview Transmission Line Project	Powerlink	From the proposed Eurombah Substation to a proposed substation at Fairview South, then continuing north to the proposed Fairview Substation.	Two proposed transmission lines to supply power to proposed substations at Fairview and Fairview South to supply power to future gas processing facilities.	Draft EIS has been prepared. Submissions being reviewed before final EIS is prepared.	2014	Unknown	Unknown	30-40 years	Located near and will supply power to facilities within Roma and Fairview gas fields.	c)
Gladstone LNG Project	Santos GLNG	Gas fields: extend from Rolleston in the north to Roma in the south and Taroom to the east. Pipeline: from gas fields to Gladstone. LNG facility: Curtis Island, near Gladstone	Development of ~2,650 wells over ~6,900 km^2. 435 km gas transmission pipeline. LNG facility of ~10 Mtpa capacity	CG approved May 2010	Commence construction 2010 to 2022	Gas fields: 960 Pipeline: 1,000	Gas fields: 820 Pipeline: 20	25 years	Makes up approved development area of GFD Project. Gas field development periods will overlap.	b)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	**Proponent**	**Location**	**Description**	**EIS current status**	**Proposed construction dates**	**Estimated construction jobs**	**Estimated operational jobs**	**Lifespan**	**Relationship to GFD Project**	**Project selection criteria**
Minyango Coal Project	Blackwater Coal	Directly south of Blackwater	Underground coal mine. 7.5 Mt/y of product coal	EIS in preparation for submission to EHP	Information not available	Information not available	Information not available	40 years	Located 40 – 45 km north of Arcadia gas field.	a)
Nathan Dam and Pipelines	Sunwater	Dam: 35 km north-east of Taroom Pipeline: from dam, through the Surat Basin to Dalby	888,000 megalitre dam, with an annual yield of 66,000 ML. 260 km trunk pipeline	CG website states that SEIS is in preparation but it has been announced that the project has been shelved.	Commence construction July 2013 to June 2016.	425	5	100 years	Dam: Located 30 km east of Scotia gas field. Pipeline: runs from dam, through Scotia gas field to Dalby.	b)
Norwood Coal Project	Metro Coal	~30 km south-west of Wandoan-	Underground coal mine. 5 Mt/y of product coal	EIS in preparation for submission to EHP	Commence construction 2015, with operations commencing 2017	300	150	20 years	Located 5 to 10 km north of Roma and 45 km south of Fairview gas field.	a)
North Surat - Collingwood Coal Project	Cockatoo Coal	12 km north-east of Wandoan and 340 km south-west of Rockhampto n.	Open cut coal mine. 6 Mt/y thermal coal.	EIS in preparation for submission to CG	Commence construction Q2 2014 to Q4 2015	1,000	400	20 years	Located immediately east of Scotia gas field.	b)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	**Proponent**	**Location**	**Description**	**EIS current status**	**Proposed construction dates**	**Estimated construction jobs**	**Estimated operational jobs**	**Lifespan**	**Relationship to GFD Project**	**Project selection criteria**
North Surat Taroom Coal Project	Cockatoo Coal Limited	3 km south-east of Taroom and 310 km south-west of Rockhampton.	Open cut coal mine. 8 Mt/y thermal coal.	EIS in preparation for submission to CG	Commence construction Q4 2013 to Q2 2015	1,000	550	25 years	Located 10 km east of Scotia gas field.	b)
Queensland Curtis LNG (QCLNG)	Queensland Gas Company	Gas fields: extend from ~30 south-west of Wandoan to ~30 km west of Dalby. Pipeline: transmission pipeline from gas fields to Gladstone. LNG facility: Curtis Island, near Gladstone	Development of ~6,000 wells over ~4,700 km^2. 380 km of gas transmission pipeline. LNG facility on Curtis Island with operating capacity of 12 Mtpa.	CG approved Jun 2010	Commence construction Q2 2010 to Q3 2013.	4,000	1,000	20 years	Located ~30 km south-west of Scotia gas field and ~25 km north-east of Roma gas field. Gas field development period will overlap.	b)
Rolleston Coal Expansion Project	Rolleston Coal Joint Venture	~25 km west of Rolleston, 270 km west of Gladstone and 120 km south-east of Emerald.	Expansion of existing Rolleston Coal mine. 10 open cut pits Expansion from 10 Mt/y to 20 Mt/y.	EIS in preparation for submission to EHP.	Information not available	Information not available	Information not available	Information not available	Located ~50 km west of Arcadia gas field.	a)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	Proponent	Location	Description	EIS current status	Proposed construction dates	Estimated construction jobs	Estimated operational jobs	Lifespan	Relationship to GFD Project	Project selection criteria
Spring Gully Power Station	Origin Energy Power Limited	80 km north-east of Roma	A 1,000 MW combined-cycle gas-fired power station, constructed in two 500 MW stages	CG approved 14 Sep 2009	Unknown	400	17	Information not available	Located ~25 km south of Fairview gas field.	b)
Springsure Creek Coal Project	Springsure Creek Coal	~40 km south-east of Emerald	Underground coal mine. 9 Mtpa of Run of Mine (ROM) coal	EHP issued public notification of EIS	Unknown	350	585	30 years	Located ~50 km north-west of Arcadia gas field.	a)
Surat Gas Project	Arrow Energy	Gas fields: Extending from Wandoan (north) to Dalby and Millmerran (east) and Goondiwindi (south)	CSG project. 7,500 CSG production wells and associated infrastructure over ~8,600 km^2.	SEIS in preparation for submission to EHP	Commence construction 2013 to 2035	1,000	400	35 years	Located immediately adjacent to Scotia gas field and extends south-east towards Dalby. Gas field development period will overlap.	a)

PROJECTS RELEVANT TO THE GFD PROJECT AREA

Project	Proponent	Location	Description	EIS current status	Proposed construction dates	Estimated construction jobs	Estimated operational jobs	Lifespan	Relationship to GFD Project	Project selection criteria
Surat Basin Railway	Surat Basin Rail	To run from just outside Wandoan (230 km north-west of Toowoomba) to just outside Banana (130 km west of Gladstone).	A 214 km railway in the Surat Basin that will connect the Western Railway system to the Moura Railway system.	CG approved 9 Dec 2010	Unknown	1,000	-	50 years	Rail line commences in the southern portion of Scotia gas field and runs north-east through Scotia gas field.	b)
Surat to Gladstone Pipeline Project	Arrow Energy	Near Dalby to Gladstone	470 km long pipeline from Dalby to Gladstone.	EHP approved Jan 2010	Unknown	300	10	40 years	Located ~5 to 10 km east of Scotia gas field.	a)
'The Range' Project	Stanmore Coal	25 km south-east of Wandoan	Open cut coal mine. 7 Mt/y product coal	EHP issued public notification of EIS	Unknown	300	500	25 years	Located ~25 km south-east of Scotia gas field.	a)
Wandoan Coal Project	Wandoan Joint Venture	5 km west of Wandoan	Open cut thermal coal mine. 30 Mt/y.	CG approved Nov 2010	Unknown	1,375	50	30 years	Located in south-west corner of Scotia gas field.	b)

Project	**Proponent**	**Location**	**Description**	**EIS current status**	**Proposed construction dates**	**Estimated construction jobs**	**Estimated operational jobs**	**Lifespan**	**Relationship to GFD Project**	**Project selection criteria**
Wandoan South to Eurombah Transmission Network Project	Powerlink	From Yuleba, transmission line to run west to Wandoan (Section 1), south to Clifford Creek (Section 2) and northwest to Eurombah (Section3).	Yuleba North Substation and a 275kV transmission line from the proposed substation to Powerlink's substations at Wandoan , Clifford Creek and Eurombah.	Final EIS released	2014	Unknown	Unknown	30-40 years	Located near Scotia gas field.	c)
Yuleba North to Blythedale Transmission Line Project	Powerlink	To run south-west from the proposed Yuleba North Substation to a proposed substation at Blythdale (25 km north-east of Roma).	Proposed 132/275kV transmission line to supply power to future gas processing facilities.	EIS in preparation	2015	Unknown	Unknown	30-40 years	Located near and will supply power to facilities within Roma and Fairview gas fields.	c)

enHealth's Health Effects of Environmental Noise

The Australia Environmental Health Committee (enHealth) (2004) undertook a review of health effects of environmental noise. While limited qualitative information is available, possible health effects from environmental noise may include:

- Noise-induced hearing impairment
- Interference with speech communication
- Disturbance of rest and sleep
- Psychophysiological, mental health and performance effects
- Effects on residential behaviour and annoyance
- Interference with intended activities.

The enHealth report '*The health effects of environmental noise – other than hearing loss*' contains four recommendations:

1. Recognise environmental noise as a potential health concern
2. Promote measures to reduce environmental noise and its health impacts
3. Address environmental noise in planning and development activities
4. Foster research on the non-auditory health impacts of noise.

Following are responses to these four recommendations.

Recognise environmental noise as a potential health concern

The guidelines suggest two actions in relation to recommendation 1:

- Recognition and awareness of the need to address environmental health effects of noise in legislation and planning
- Adoption of the *WHO Guidelines for Community Noise* (WHO, 1999).

The WHO guidelines specify that the following noise levels should be achieved in residential premises:

- Bedrooms (internal) - 30 dBA LAeq (steady noise)
- Bedrooms (internal) - 45 dBA LAmax (intermittent noise)
- Living areas (internal) – 35 dBA LAeq (steady noise)
- Living areas (outdoor) – 50 dBA LAeq (steady noise).

The noise criteria determined using the noise assessment guideline are below the most stringent of the WHO noise levels, and are hence considered adequate to protect residents from adverse health effects.

The above 30 dB LAeq guideline for bedrooms (internal) conservatively equates to 35 dB LAeq external assuming a conservative 5 dBA façade noise reduction. Given that the proposed Noise Assessment Guideline criterion is 28 dB LAeq and including 5 dBA as a conservative façade noise reduction (AS3671 recommends the use of 10 dBA and indeed the WHO guideline recommends the use of 15 dBA as a façade noise reduction), it is considered that Noise Assessment Guideline criterion will also ensure compliance with the WHO guidelines.

Promote measures to reduce environmental noise and its health impacts

The enHealth document contains many 'high level' actions in this recommendation in relation to education programs, mitigation and licensing controls, relevant standards and product labelling. This recommendation does not contain any relevant recommendations in relation to this study.

Address environmental noise in planning and development activities

The enHealth document contains many 'high level' actions in this recommendation in relation to integrating noise into planning processes and national consistency for limits that are not relevant to this study. The one relevant recommendation is that baseline environmental noise levels should be undertaken (where appropriate) to inform planning actions. This is a standard approach in Queensland and has been done for this study as outlined in **Section 0** of this technical report.

Foster research on the non-auditory health impacts of noise

The enHealth document recommends that research be undertaken in many areas of noise to further understand the non-auditory health effects of noise.

There is much ongoing work still to be done in this area but the following information has been provided to assist in understanding the primary concerns in this area of acoustics.

Fauna

Introduction

The effect of noise from human activities on fauna is increasingly a subject of concern in the community when proposing developments such as new infrastructure, mines or industrial developments. The potential effects of noise on wildlife include physical damage to hearing, increased energy expenditure or physical injury while responding to noise, interference with normal animal activities and impaired communication. Ongoing impacts of these effects might include habitat loss through avoidance, reduced reproductive success and increased mortality.

While noise impacts on people are commonly regulated, there are no government policies or other widely accepted guidelines as to noise levels or thresholds that may have an adverse effect on wildlife. One reason for the lack of guidelines is that noise effects on most wildlife species are poorly understood (Larkin et al. 1996, Brown 2001; OSB 2003, summarised in AMEC 2005). The lack of understanding of noise effects on wildlife is understandable when the following points are considered:

- Response to noise disturbance cannot be generalised across species or among genuses. Studies of one species cannot be extrapolated to other species.
- Hearing characteristics are species-specific. For example, noise impacts on humans are determined using a frequency weighting filter (A-weighting) which corresponds to human hearing characteristics, determined through laboratory testing. The frequency-dependent hearing characteristics of animals cannot be determined in this way.
- When studying of noise effects on animals it can be difficult to separate noise effects from other sensory disturbing effects (e.g. visual or olfactory cues).
- Experimental research in a laboratory is not always applicable in a natural setting.

As with humans, an animal’s response to noise can depend on a variety of factors, including noise level, frequency distribution, duration, number of events, variation over time, rate of onset, noise type, existence and level of ambient noise, time of year, and time of day. The animal’s location, age, sex, and past experience may also affect their response to noise.

The US FHA review summarises the sensitivities of various groups of wildlife to noise as follows:

- Mammals < 10 Hz to 150 kHz ; sensitivity to -20 dB
- Birds (more uniform than mammals) 100 Hz to 8-10 kHz; sensitivity at 0-10 dB
- Reptiles (poorer than birds) 50 Hz to 2 kHz; sensitivity at 40-50 dB
- Amphibians 100 Hz to 2 kHz; sensitivity from 10-60 dB.

Despite the difficulties associated with assessing noise impacts on animals, studies have been done that can assist in drawing some general conclusions. The literature in the field has been collated in a number of reviews including AMEC 2005 (noise from mining operations), Dawe and Goosem 2008 (road traffic noise impacts, an Australian study), Manci et al. 1988 (effect of aircraft noise and sonic booms), and US FHA 2004 (road traffic noise impacts). Some key findings of these reviews are summarised here. For original references, the reader is directed to these review studies. A tabular summary of studies and effects is given in Manci et al.

Mammals

Manci et al. (1998) state that:

> *Sound levels above about 90 dB are likely to be adversive to mammals and are associated with a number of behaviours such as retreat from the sound source, freezing, or a strong startle response. Sound levels below about 90 dB usually cause much less adversive behavior. Laboratory studies of domestic mammals have indicated that behavioural responses vary with noise types and levels, and that domestic animals appear to acclimate to some sound disturbances.*

The US FHA review notes that some mammals avoid roads, and that in some cases this avoidance behaviour has been attributed to noise.

Very few of the mammal studies in the literature state absolute levels above which physiological damage may occur. One case described in Manci et al. (1998) is a study of guinea pigs showing anatomical damage and hearing loss when exposed to sonic booms at 130 dB.

Birds

Measures of absolute auditory sensitivity in a wide variety of bird species show a region of maximum sensitivity between 1 and 5 kHz, with a rapid decrease in sensitivity at higher frequencies. The data suggests that in this frequency range birds show a level of hearing sensitivity that is similar in most respects to that found for the most sensitive mammals, with avian performance clearly inferior above and below this range of frequencies (Manci et al. 1998).

The general conclusion of the US FHA review is that some (although not all) bird species are sensitive to road traffic noise at least during breeding and that the distances over which this effect is seen can vary considerably, from a few meters to more than 3 km away. Reduced bird diversity and density of bird life near to roads, in some cases associated with average noise levels above 50 dBA.

Dawe and Goosem state that:

> *'Anthropogenic noise can also trigger flight and alert responses in birds and altered behaviour after the noise disturbance, which can lead to reduced breeding success, at noise levels ranging from 65-85 dB(A). Complete habituation to such disturbance does not always occur, even in less noise-sensitive species.'*

With respect to peak noise levels such as sonic booms, studies of various species have shown startle responses for a range of noise levels from 70 dBA up to 145 dBA. For example, birds may flush from the nest in response to a sudden loud noise, but in most cases will return within ten minutes.

Reptiles

Sound perception appears to be subordinate in importance to vision or chemoreception in the activities of most reptiles, but studies have shown that certain desert reptiles are sensitive to low-intensity sound (Manci et al. 1998). Noise may be of more adaptive significance for nocturnal species because full use cannot be made of vision. Critical environmental sounds are often of relatively low intensity (eg the movement of insect prey and predators such as snakes and owls).

Some studies reviewed by Manci et al. (1998) indicate hearing damage to some lizard species after exposure to steady noise levels above 95 dB.

Amphibians

Sound influences the activities of most amphibians and plays a significant role in the reproductive behaviour of many, but not all, species (Manci et al. 1998). Dawe and Goosem consider that the degree to which traffic noise affects frog densities remains unclear, although some factor associated with roads and traffic has been shown to reduce frog populations.

Specific noise levels which may result in an adverse impact on amphibians are not available in the literature.

Invertebrates

Manci et al. describe several studies on the effects of noise on insects. In some cases, noise has been studied with a view to controlling pest insects such as meal-moths and flour beetles, with some success in reducing hatching from the larval stage. Some studies have shown reduced lifespan in insects exposed to noise, and reduced number of eggs produced by females.

Some insects (including bees) stop moving when exposed to high noise levels. Honey bees ceased moving for up to 20 minutes in response to frequencies between 200 and 2,000 Hz with intensities varying from 107-119 dB and did not appear to habituate to the sound (Manci et al. 1998).

Conclusions

It is clear that noise can have adverse effects on wildlife and domesticated mammals, with different species being more or less sensitive to noise. As with humans, extremely high noise levels can result in hearing damage or other physiological effects. At lower noise levels, it seems likely that animals avoid anthropogenic noise sources and prefer to occupy areas further from noise sources.

On the basis of the literature, and noting the difficulties inherent in assessing noise impacts on fauna described above, the following conclusions are drawn:

- Adverse impacts on fauna are highly unlikely at noise levels below 50 dBA LAeq, and unlikely at noise levels below 65 dBA LAeq.
- Long-term adverse impacts on fauna are unlikely to arise from short duration, high noise events. These events may, however, result in a short-term startle response.
- Very high maximum noise levels may result in hearing loss or other long-term physiological effects. The threshold of hearing damage is likely to be species and frequency dependent, and as with humans, damage may be cumulative over time.

With reference to the GFD Project, it is considered that fauna (including domesticated mammals) exposed to less than **65 dBA LAeq** are unlikely to experience adverse impacts.

VIBRATION CRITERIA

When dealing with vibration from construction and operations, the effects in buildings can be divided into the following main categories:

- Human comfort.
- Structural damage.
- Safe vibration levels for common services.
- Effects of vibration on building contents.

Human comfort

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard *DIN 4150 Part 2-1975*. On this basis, the resulting degrees of perception for humans are suggested by the continuous vibration level categories given in **Table E1**.

Table E1 Vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having frequency content in the range of 8 Hz to 80 Hz.

Table E1 suggests that people will just be able to feel continuous floor vibration at levels of about 0.15 mm/s and that the motion becomes “noticeable” at a level of approximately 1 mm/s.

Guidance in relation to assessing the potential human disturbance from ground-borne vibration inside buildings and structures is contained in Australian Standard AS 2670.2-1990 *“Evaluation of Human Exposure to whole-body vibration Part 2 Continuous and shock induced vibrations in buildings (1 Hz to 80 Hz)”.*

The AS 2670.2 gives guidance to satisfactory vibration velocity levels based on the RMS or “root mean squared” vibration levels. The RMS vibration level can be converted to peak vibration level by applying the appropriate “crest” factor (ie ratio of the peak level to RMS level) to obtain a “peak” vibration level. Crest factors will vary from 1.4 for construction activities of a sinusoidal nature (eg continuous vibratory rolling and rotating plant) up to 4 or more for intermittent activities such as rockbreaking and blasting.

Satisfactory magnitudes of peak vibration velocity (ie below which the probability of “adverse comment” is low) from AS 2670.2 are shown in **Table E2** (for generally sinusoidal vibration).

Table E2 Satisfactory level or peak vibration velocity (8 Hz to 80 Hz)

Type of space occupancy	Time of day	Satisfactory peak vibration levels in mm/s over the frequency range 8 hz to 80 hz			
		Continuous or intermittent vibration		Transient vibration excitation with several occurrences per day	
		Vertical	Horizontal	Vertical	Horizontal
Critical working areas (eg some hospital operating theatres, some precision laboratories, etc)	Day Night	0.14	0.4	0.14	0.4
Residential	Day Night	0.3 to 0.6 0.2	0.8 to 1.5 0.6	4 to 13 0.2 to 3	13 to 36 0.6 to 8.4
Offices	Day Night	0.6	1.7	8 to 18	24 to 52

As can be seen from the last two columns of **Table E2** situations can exist where vibration magnitudes above those generally corresponding to a low probability of reaction, particularly for temporary disturbances and infrequent and intermittent events such as those associated with blasting, can be tolerated. With close cooperation and liaison with the occupants of the potentially affected properties, significantly higher levels of short-term vibration could be tolerated by many people for construction projects. In many instances there is a trade-off between the magnitude and duration of construction related vibration (eg rockbreaking versus blasting).

Table E2 indicates that continuous floor vibration levels above which "adverse comment" in residences and offices may arise during daytime range from approximately 0.3 mm/s to 0.6 mm/s.

Structural Damage

In terms of relevant vibration damage criteria, *British Standard 7385: Part 2-1993 Evaluation and measurement for vibration in buildings Part 2* is a definitive standard against which the likelihood of building damage from ground vibration can be assessed.

Although there is a lack of reliable data on the threshold of vibration-induced damage in buildings both in countries where national standards already exist and in the UK, BS 7385: Part 2 has been developed from an extensive review of UK data, relevant national and international documents and other published data. The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration which are considered in the standard include blasting, demolition, piling, ground treatments (ie compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

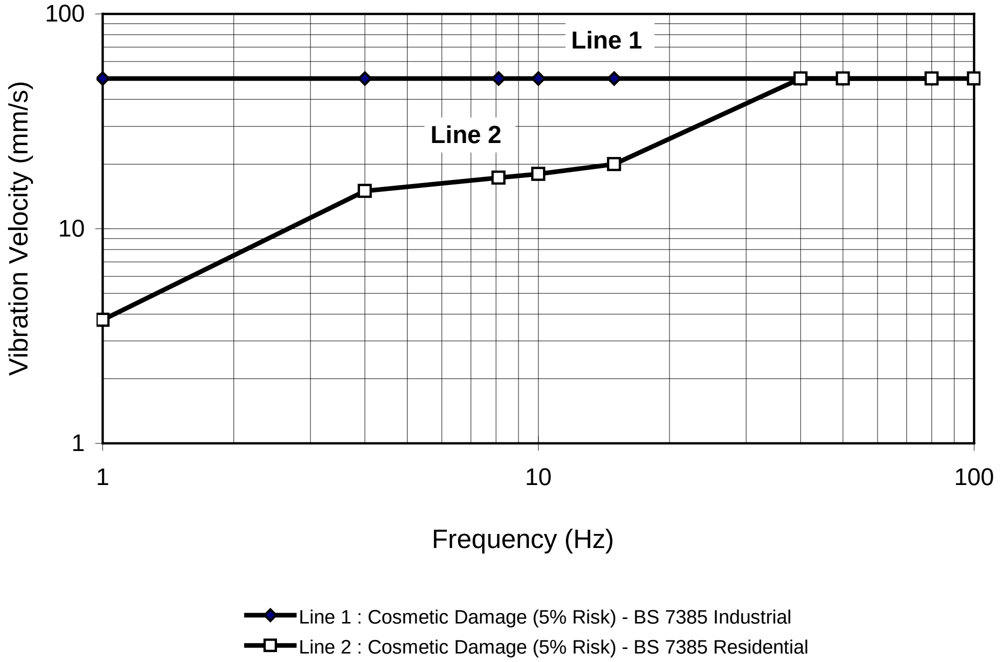
As the strain imposed on a building at foundation level is proportional to the peak particle velocity but is inversely proportional to the propagation velocity of the shear or compression waves in the ground, this quantity (ie peak particle velocity) has been found to be the best single descriptor for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

The guide values from this standard for transient vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in **Table E3** and graphically in **Figure E1**.

Table E3 BS 7385 – transient vibration guide values for cosmetic damage

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

Figure E1 Graph of transient vibration guide values for cosmetic damage



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

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of low reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table E3** should not be reduced for fatigue considerations.

Nevertheless, the standard states that the guide values in **Table E3** relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table E3** may need to be reduced by up to 50%.

It is noteworthy that additional to the guide values nominated in **Table E3**, the Standard states that:

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

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

Safe vibration levels for common services

Vibration due to the construction process has the potential to effect services such as buried pipes, electrical and telecommunication cables.

German Standard DIN 4150-3 1999 *"Structural Vibration – Part 3: Effects of vibration on structures"* provides guidance on safe vibration levels for buried pipe work. The levels assume "current technology" as special considerations must be applied for systems associated with older structures such as might occur in the vicinity of Heritage Listed buildings. **Table E4** details the DIN 4150-3 limits for short-term vibration. The levels apply at the wall of the pipe. For long-term vibration the guideline levels presented in **Table E4** should be halved.

Table E4 DIN 4150 Part 3 – Damage to buried pipes – guidelines for short-term vibration

Pipe material	Peak wall vibration velocity
Steel (including welded pipes)	100 mm/s
Clay, concrete, reinforced concrete, prestressed concrete, metal with or without flange (other than steel)	80 mm/s
Masonry, plastic	50 mm/s

Note: For gas and water supply pipes within 2 m of buildings, the levels given in **Table E4** should be applied. Consideration must also be given to pipe junctions within the building structure as potential significant changes in mechanical loads on the pipe must be considered.

Recommended vibration criteria for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s.

It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out.

Effects of vibration on building contents

Over the frequency range typical of vibration in buildings from construction and excavation activities, industrial vibration, road and rail traffic (approximately 8 Hz to possibly 100 Hz), the threshold for visible movement of susceptible building contents (ie plants, hanging pictures, blinds, etc) is approximately 0.5 mm/s and audible rattling of loose objects (ie crockery) generally does not occur until levels of about 0.9 mm/s are reached.

For delicately balanced objects, rattling may sometimes occur at lower vibration levels. Window rattling may also be excited acoustically (ie by sound pressure waves, which may be thought of as vibration in the air).

VIBRATION CRITERIA

In any premises, day-to-day activities (eg, footfalls, doors closing, etc) will cause levels of vibration in floors and walls that exceed 1 mm/s (sometimes by quite considerable margins), and therefore visible movement and rattling are often observed. In most instances however, such movement is considered normal, and vibration levels of even much greater magnitude do not result in damage to the objects or building contents.

Potentially vibration-susceptible building contents include sensitive instrumentation, computers and other electronic equipment, although such items are not usually kept in residences (apart from personal computers which are considerably more robust). Typical maximum floor vibration levels for satisfactory operation of such sensitive items are:

- 0.5 mm/s to 2 mm/s — Precision balances; Some optical microscopes
- 1 mm/s to 5 mm/s — Large computer disk drives; Sensitive electronic instrumentation

Very short duration vibration events, for example vibration from infrequent impulsive vibration, could be permitted to cause somewhat higher levels, depending on vibration frequency content and on the specific susceptibility of particular objects and their location.

The actual levels of vibration induced by a source outside a building are a function of the particular ground conditions, the foundation/footing interaction, location of the receptor within the building and the nature of the building and its floor.

Table F1 Noise source data – construction

Task	Plant item	Typical model / size	Noise descriptor	SWL	A-weighted sound power level L_{Aeq} in octave bands centre frequency (Hz)								
					31.5	63	125	250	500	1k	2k	4k	8k
General construction	4WD		L_{Aeq}	92					92				
	Air compressor	600CFM	L_{Aeq}	103	58	66	76	82	91	97	98	96	91
	Articulated dump truck	40T	L_{Aeq}	110	67	86	97	99	104	105	103	100	95
	Backhoe		L_{Aeq}	100	62	83	91	92	93	95	93	88	80
	Bobcat		L_{Aeq}	98					98				
	Bored piling rig		L_{Aeq}	110					110				
	Compactor	CAT825	L_{Aeq}	106	55	73	88	98	99	100	100	94	84
	Concrete Pump and Vibrator	-	L_{Aeq}	110	67	86	97	99	104	105	103	100	95
	Concrete truck	-	L_{Aeq}	109	66	85	96	98	103	104	102	99	94
	Crane 250t		L_{Aeq}	110		87	96	99	105	105	102	93	83
	Dozer	D6	L_{Aeq}	106	67	78	95	96	101	100	99	93	82
	Dozer	D8	L_{Aeq}	108	67	84	93	97	105	101	100	98	90
	Excavator - large	60T	L_{Aeq}	111	70	84	97	100	107	105	103	95	81
	Excavator - medium	30T	L_{Aeq}	106	65	79	92	95	102	100	98	90	76
	Excavator - small	12 T	L_{Aeq}	103	62	76	89	92	99	97	95	87	73
	Forklift		L_{Aeq}	99					99				
	Front-end loader	CAT988	L_{Aeq}	107	68	79	95	100	99	100	100	94	88
	Generator	110 kVa	L_{Aeq}	92	57	78	85	86	83	85	85	79	65
	Grit/sand blaster		L_{Aeq}	108					108				
	Grader	14G	L_{Aeq}	106		82	91	94	96	104	99	95	84
	Hand-held grinder		L_{Aeq}	110						110			
	Hand tools		L_{Aeq}	95					95				
	Haul truck		L_{Aeq}	110	62	81	92	94	104	104	107	95	86

Task	Plant item	Typical model / size	Noise descriptor	SWL	A-weighted sound power level LAeq in octave bands centre frequency (Hz)								
					31.5	63	125	250	500	1k	2k	4k	8k
General construction cont.	HDD (drill rig plant) or boring machine		LAeq	LAeq					113				
	HDD (pipe stringing plant)		LAeq	LAeq					111				
	Lighting tower		LAeq	95	65	78	83	81	87	87	89	88	75
	Mobile crane - 20T	Franna - 20T	LAeq	102		79	88	91	97	97	94	85	75
	Mobile crane - 50T	Franna - 50T	LAeq	105		82	91	94	100	100	97	88	78
	Mobile Crushing and Screening Unit		LAeq	LAeq	67	88	99	111	116	118	115	100	100
	Mulcher		LAeq	110					110				
	Padder	Ozzi	LAeq	110	88	96	103	103	102	104	103	97	90
	Reverse alarm		LAeq	105						105			
	Rockhammer (attached on excavator)		LAeq	122	72	93	97	105	112	113	115	118	114
	Vibratory Roller	LAeq	LAeq	107	57	75	90	100	101	102	100	94	86
	Scissor lift/boom lift		LAeq	99					99				
	Scraper	CAT631	LAeq	108	67	86	96	98	102	103	102	95	86
	Side boom	CAT	LAeq	107	66	83	92	96	104	100	99	97	89
	Trencher		LAeq	115	66	88	98	104	109	107	110	108	104
	Truck - B-double		LAeq	106	63	82	93	95	100	101	99	96	91
	Water cart		LAeq	104	67	74	86	90	96	100	99	94	85
	Welding rig		LAeq	101	60	73	78	82	93	93	99	90	81
Well construction	Drill rig (mud)		LAeq	117	73	106	103	104	107	111	112	108	100
	Drill rig (air)	Normal drilling	LAeq	122	63	73	94	108	109	114	116	119	102
		Operating Blooie Line	LAeq/LAmax	130	62	86	97	101	120	121	127	123	116
	Completion drill rig	Normal drilling	LAeq	117	73	106	103	104	107	111	112	108	100
		Operating Blooie Line	LAeq/LAmax	130	62	86	97	101	120	121	127	123	116
	Hydraulic stimulation		LAeq	120					120				

Task	Plant item	Typical model / size	Noise descriptor	SWL	A-weighted sound power level L_{Aeq} in octave bands centre frequency (Hz)								
					31.5	63	125	250	500	1k	2k	4k	8k
Well construction cont.	Cavitation stimulation		L_{Aeq}	120					120				
	Impacts of drill rods / casings		L_{Amax}	110						110			

Note: Noise source data in **Table F1** are sourced from SLR's noise source database, based on measurements and vendor data collated for a number of recent natural gas projects.

CONSTRUCTION STAGES

Table G1 Drilling and completions construction staging and typical plant items

Stage	Description	Typical plant items
Well pad construction	Clearing of vegetation and topsoil; levelling ground and construction of earthen/flare pit.	1x 14 g grader 1x Dozer 1x Excavator 1x Mulcher
Drilling	Rig setup and drilling of well	1x Drill rig Auxiliary plant typically include: - Mud pump - Genset - Hydraulic power unit
Hydraulic fracturing	Fracturing.	
Completions rig	Rig setup and completion/workover of well	1x Completion drill rig Auxiliary plant typically include: - Genset - Hydraulic power unit - Booster compressors - Blooie line

Table G2 Facilities construction staging and typical plant items (medium hub compressor facility)

Stage	Description	Typical plant items
Clear and grade	Clearing of vegetation and topsoil; levelling ground	2x 14g grader 2x Dozer 2x Excavator 2x Water truck 2x Dump trucks 2x Haul trucks 2x Vibratory rollers 2x Scrapers 1x Mulcher
Concrete pad and foundations	Pouring concrete pad for compressors and surface facilities	2x Concrete trucks 2x Concrete pumps and vibrators 2x Piling rig (bored)
Set up of facilities	Erecting office, fences	3x Franna 20 t crane 2x scissor lifts/boom lifts 2x semi-trailers 2x Weld Rig 2x Angle grinders Hand tools Post hole diggers
Construction of compressors and coolers	Installing compressors and coolers	1x 250 t crane 1x Franna 20 t crane 2x scissor lifts/boom lifts 2x semi-trailers 2x Weld rig Hand tools

Table G3 Gathering and transmission line construction staging and typical plant items

Stage	Description	Typical plant items
Clear and grade	Graders, bulldozers and rakes are utilised for clearing. Top soil and vegetation are stockpiled for later reuse.	2x 14 g grader 2x Dozer 1x Excavator 1x Water truck 2x Dump trucks 2x Four wheel drive 1x Mulcher
Stringing	Pipe elements are laid end to end in the ROW. If required, pipe sections are bent to match changes in the alignment of the pipeline.	1x Excavator 1x B-double for pipe elements 2x Four wheel drive
Welding and joint coating	Pipe sections are welded together.	1x Sideboom (on tractor/dozer) 1x Weld rig 1x Four wheel drive 1x Grit/sand blasting
X-raying and pressure testing	The welds are inspected using x-ray detectors and pressure testing is undertaken.	1x Excavator 1x Weld rig 2x Four wheel drive 2x Air compressors
Trenching	Excavating the trench	1x Trencher
Lowering	Side booms are utilised to lower the pipe into the trench.	4x Sideboom (on tractors/dozers)
Padding and backfilling	Padding machines are used to sift the excavated material. The fine material is used to pad beneath the pipe and to fill the trench.	1x Padder 1x Excavator 1x Four wheel drive 1x Dozer
Tie-ins, push sections and road crossings	These activities are required where tie to existing infrastructure is required or the route crosses existing infrastructure such as a road.	1x Dozer 1x Excavator 1x Weld rig 1x Four wheel drive 1x Boring machine or HDD
Restoration and rehabilitation	This phase may include contouring and revegetation of the work area.	1x Dozer 1x Grader 1x Excavator 2x Four wheel drive 1x Dump truck

Table G4 Borrow pit construction staging and typical plant items

Stage	Description	Typical plant items
Excavating material	Excavating material and crushing.	2x B-doubles 2x Excavator 1x Mobile crushing and screen plant 2x FEL

Table G5 Laydown Construction Area Staging and Typical Plant Items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil; levelling ground and erecting fence.	1x Dozer 2x Excavator 1x Water truck 2x Dump Trucks 1x Four wheel drive
Laydown Yard Operations	General operating activities of the laydown area.	2x Franna 20 t cranes 2x Forklifts 2x B-doubles

Table G6 Communication infrastructure construction staging and typical plant items

Stage	Description	Typical Plant Items
Clear and grade	Clearing of vegetation and topsoil; levelling ground and erecting fence.	1x Dozer 2x Excavator 1x Water truck 2x Dump trucks 1x Four wheel drive
Civil works	Concrete foundations, erecting tower and surface facilities.	1x Concrete truck 1x Concrete pump and vibrator 2x Franna 50 t cranes 1x Weld rig 1x Piling rig (bored) Hand tools

Table G7 Road/access track construction staging and typical plant items

Stage	Description	Typical plant items
Clear and grade	Clearing of vegetation and topsoil; levelling ground and erecting fence.	1x Dozer 1x Grader 1x Water truck 1x Mulcher
Road surfacing	Compacting and provide surface gravel.	1x Vibratory roller 2x B-doubles side tippers 1x Grader 1x Water truck

Table H1 Noise source data – operation

Source/activity	Plant item	Quantity	Source height (m)	SWL (per unit)	A-weighted sound power level L_{Aeq} in octave bands centre frequency (Hz)								
					31.5	63	125	250	500	1k	2k	4k	8k
Hub gas compression facility (non-electrified)	Hub gas compression facility package breakout	4	3.0	112	83	96	101	102	102	100	99	108	103
	Hub gas compression facility package exhaust	4	16.0	117	91	106	105	106	110	111	108	106	107
	Hub gas compression facility after-cooler fans	4	5.0	107					107				
	Lube oil coolers	12	2.0	107	85	90	97	100	101	102	97	90	85
	Nodal compressors (screw)	8	2.0	108	85	92	101	106	96	88	83	74	69
	Lube oil coolers (including pumps, fans and motors)	8	2.0	108	56	75	90	99	102	103	100	96	90
	TEG units	3	2.0	101	49	70	82	89	96	96	94	88	77
	Hub gas compression facility gas turbine alternator package breakout	4	3.0	108	82	95	98	97	99	96	95	104	99
	Hub gas compression facility gas turbine alternator package exhaust	4	16.0	117	91	106	105	106	110	111	108	106	107
	GTA lube oil cooler fans	4	2.0	104	82	87	94	97	98	99	94	88	82
	Transformers (25MVA)	3	2.0	79		54	71	73	70	73	70	67	58
Hub compressor facility (electrified)	Hub gas compression facility package breakout	4	3.0	101	47	78	83	87	93	96	96	93	84
	Hub gas compression facility after-cooler fans	4	5.0	107					107				
	Lube oil coolers	12	2.0	107	85	90	97	100	101	102	97	90	85
	Nodal compressors (screw)	8	2.0	108	85	92	101	106	96	88	83	74	69
	Lube oil coolers (including pumps, fans and motors)	8	2.0	108	56	75	90	99	102	103	100	96	90
	TEG units	3	2.0	101	49	70	82	89	96	96	94	88	77
	Transformers (25MVA	3	2.0	79		54	71	73	70	73	70	67	58
Nodal compression facility (Non-electrified)	Nodal compression facility packages (including compressor, lube oil coolers and CAT G3608 engines)	3	3.0	117	83	94	98	104	110	112	111	109	93
	Reciprocating engines (75 MW)	2	2.0	92	57	78	85	86	83	85	85	79	65
	TEG units	2	2.0	101	49	70	82	89	96	96	94	88	77

NOISE SOURCE DATA – OPERATION

Source/activity	**Plant item**	**Quantity**	**Source height (m)**	**SWL (per unit)**	**A-weighted sound power level L_{Aeq} in octave bands centre frequency (Hz)**								
					31.5	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Water treatment facility	Pre-treatment (2x pumps)	1	1.5	96	46	60	71	80	86	92	90	86	78
	Reverse osmosis skid containers (1x pump and 1x blower)	5	1.5	93	43	61	69	78	84	89	87	83	75
	Post treatment (2x pumps)	1	1.5	96	46	60	71	80	86	92	90	86	78
Non-electrified wells	Generator and pump. The generator is the dominant noise source.	1	1.5	95	57	78	85	87	86	90	89	84	75
Electrified or free flowing wells	Gas flow generated noise (approximately 5 TJ/d choke valve 100% open). SWL from electrified pump motor is approximately 10 dBA below gas flow generated noise (ie gas flow is the dominant noise source).	1	1.5	84					84				
Flaring	Hub gas compression facility flare stack package (representable for an approximately 160 MMSCFD size flare)	1	3.0	126	98	107	112	113	117	122	119	114	105
Accommodation camp (assume 400 man camp)	Air-conditioning units (per 400 beds)	240	1.0	80		74	73	73	70	70	67	62	
	Generator 500 kVa	5	2.0	99		90	95	95	90	85	80	80	

Note: Noise source data in **Table H1** are sourced from SLR's noise source database, based on measurements and vendor data collated for a number of recent natural gas projects. Noise data for the free flowing production well is sourced from noise monitoring data provided by Santos GLNG.