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Bowen Gas Project SREIS

AUSTRALIA

Supplementary Noise and Vibration Technical Report

March 2014
42627140/L/1

Prepared for:
Arrow Energy Pty Ltd

Prepared by URS Australia Pty Ltd

DOCUMENT PRODUCTION / APPROVAL RECORD

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Report Name:
Bowen Gas Project SREIS

Sub Title:
Supplementary Noise and Vibration Technical Report

Report No.
42627140/L/1

Status:
FINAL

DOCUMENT REVISION RECORD

Issue No.	Date	Details of Revisions
FINAL	21/02/2014	Final revision

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ABBREVIATIONS

Abbreviation	Description
%	per cent
°C	degrees Celsius
CGPF	central gas processing facility
CSG	coal seam gas
dB	decibels
dB(A)	decibels, A–weighted
EHP	Queensland Department of Environment and Heritage Protection
EIS	environmental impact statement
EPA	Environmental Protection Agency (obsolete in Queensland: now EHP)
EP Act	*Environment Protection Act 1994* (QLD)
EP Regulation	Environment Protection Regulation, 2008 (QLD)
EPP (Noise)	Environment Protection (Noise) Policy, 2008 (QLD)
FCF	field compression facility
Hz	hertz
IPF	integrated processing facility
km	kilometre
kVA	kilovolt amps
kW	kilowatt
$L_{A10,t}$	statistical noise level exceeded for 10% of the time period t,
$L_{A10, 18hr}$	Average of the $L_{A10,1hr}$ nose levels between 6:00 am and 12:00 midnight
L_{eq}	time-averaged sound pressure level, over time period *t*
$L_{Aeq,t}$	time-averaged A-weighted sound pressure level, over time period *t*
$L_{Aeq,adj,t}$	time-averaged A-weighted sound pressure level, over time period *t,* adjusted for noise character (tonality and/or impulsiveness)
m	metre
m/s	metres per second
MW	megawatt
ppv	peak particle velocity
Project (the)	Bowen Gas Project
QLD	Queensland
SREIS	Supplementary Report to the EIS
TJ	terajoule (10^{12} joules)
ToR	Terms of Reference as defined by Part 4 of the *State Development & Public Works Organisation Act 1971*
WTF	water treatment facility

EXECUTIVE SUMMARY

Arrow Energy Pty Ltd (Arrow) proposes an expansion of its gas operations in the Bowen Basin through the Bowen Gas Project (the Project). A noise and vibration assessment was submitted for inclusion in the Environmental Impact Statement (EIS) for the Project (Noise and Vibration Technical Report (Appendix S) of the EIS). Since publication of the EIS for public comment, Arrow's field development plan and conceptual design for the Project has advanced. This progression is the result of ongoing exploration activities that have improved Arrow's understanding of the gas resource and the evolution of Arrow's concept design, planning and operational processes. This has led to a number of conceptual design changes to the Project.

Arrow is required to prepare a supplementary report to the EIS (SREIS) to:

- Present information on any material changes to the project description;
- Address issues identified in the EIS requiring further consideration and/or information; and
- Respond to comments raised in the submission on the EIS.

The objective of this SREIS noise and vibration assessment is to evaluate noise and vibration emissions from the Project as a result of the proposed Project design changes. This report describes the changes to the noise and vibration assessment for the EIS resulting from refinements to the project description, the inclusion of updated and new datasets and supplementary information requested by stakeholders. The report provides an evaluation as to whether the estimated noise levels provided in the EIS are still relevant following project description refinements and whether the mitigation measures applied for the EIS are still appropriate to address identified impacts.

The key differences to the project description between the EIS and SREIS relevant to the noise and vibration assessment are:

- The well designs, including:
  - The duration of well drilling and well pad construction activities;
  - The number of wells per well pad; and
  - The well pad layout as pairs of well pads with 400 m separation;
- The design and number of the field compression facilities (FCFs);
- The design and number of the central gas processing facilities (CGPFs), including the co-location of water treatment facilities;
- The type, rate and frequency of occurrence of flaring at FCFs, and
- The type, rate and frequency of occurrence of flaring at CGPFs.

The methodology applied to the assessment of noise and vibration impacts was the same in the EIS and SREIS.

Further assessment of cumulative and localised impacts is still recommended at significant infrastructure development milestones or phases. These could include instances where clustering of sources occurs, infrastructure is developed in close proximity to existing or proposed sources, or infrastructure is developed in close proximity to sensitive receptors.

In the EIS, noise mitigation measures were established to ensure the Project is environmentally acceptable whilst still remaining cost effective. These recommended measures remain valid in the SREIS and have been used to demonstrate that the acoustic criteria can be achieved using a combination of noise attenuation by distance and engineering noise control treatments.

1 INTRODUCTION

This Supplementary Noise and Vibration Impact Assessment report forms part of the Supplementary Report to the Environmental Impact Statement (SREIS) for the Bowen Gas Project (the Project).

This assessment investigates the potential for any change to the noise and vibration impact of the Project as a result of updates to the project description since exhibition of the Environmental Impact Statement (EIS). The assessment specifically addresses Project components that have been affected by these updates as well as any noise-related submissions received during the exhibition period and supplements the assessment undertaken for the EIS.

The assessment undertaken for the EIS is detailed in the Noise and Vibration Technical Report (Appendix S) of the EIS.

2 PROJECT DESCRIPTION

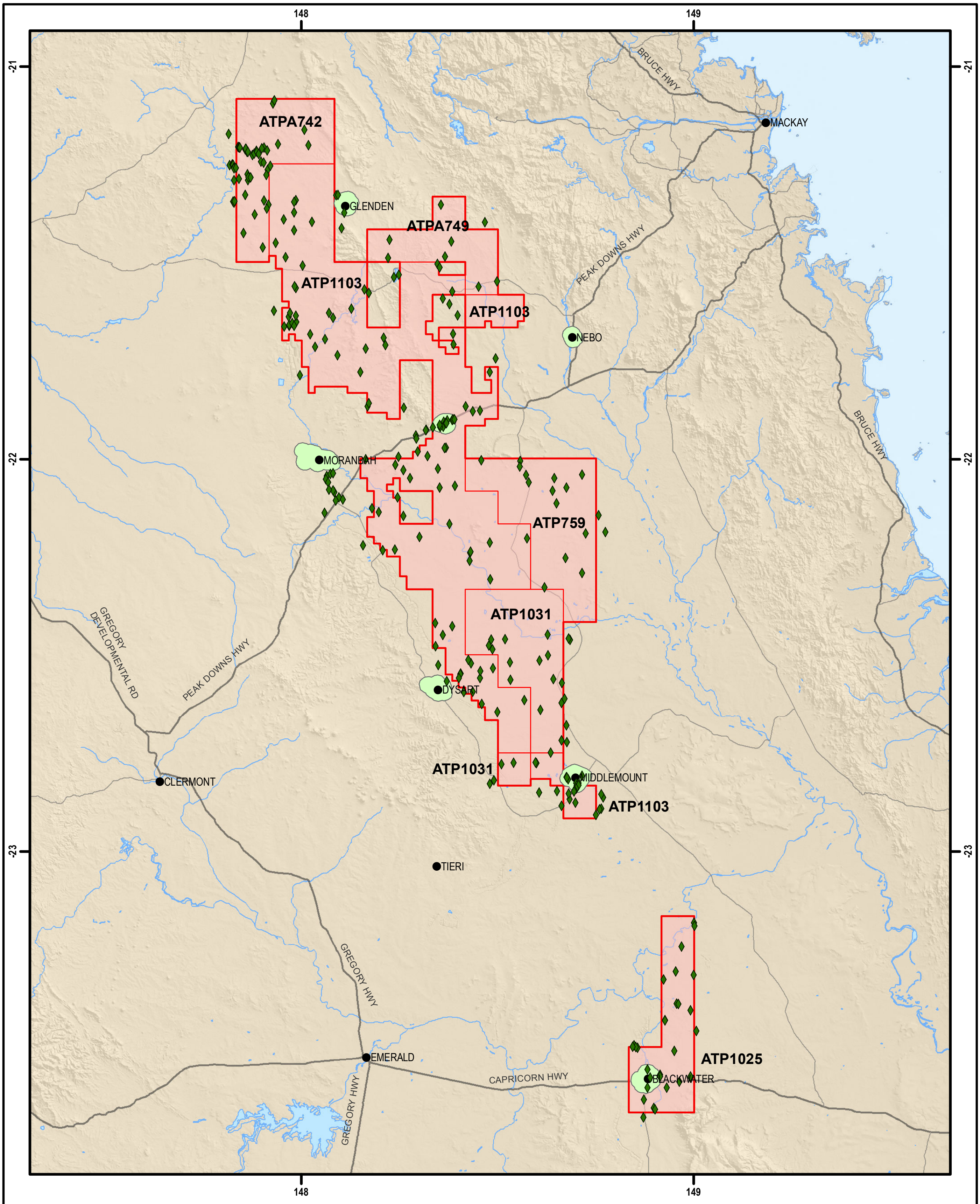
Since preparation of the Project EIS, Arrow has improved its knowledge of the gas reserves and refined the field development plan and design of Project infrastructure.

The refinements, which are applicable to the noise and vibration assessment, include:

- Major infrastructure components have changed:
  - The location of development areas have been revised; this influences the indicative location of gas production facilities (central gas processing facilities (CGPFs) and field compression facilities (FCFs));
  - The number of CGPFs and integrated processing facilities (IPFs) have reduced from seven in the EIS to two CGPFs only in the SREIS. Note the term IPF no longer applies. The CGPFs will be co-located with water treatment facilities (WTFs);
  - The number of FCFs have increased from 10 to 33, as a result of the drainage area radius of each gas field being reduced from approximately 12 km to 6 km;
  - The number of production wells have reduced from 6,625 to approximately 4,000. Wells will be clustered together onto common well pads where possible, with a maximum of 12 wells per pad (6 production and 6 lateral wells);
  - Note, with the above changes to Project infrastructure, there has not been a change to the overall installed compression capacity.
- Electrical power supply options have changed:
  - Grid power supply based on connection to existing electricity infrastructure is the preferred SREIS power supply option;
  - Temporary power generation using coal seam gas (CSG) at the Project production facilities (CGPFs and FCFs) will be retained as a power supply option for the first two years of Project life. This scenario is in case the network service provider is unable to provide powerlines at the commencement of operations. The temporary power installed at the FCFs over the first two years will provide power for the wells through an overhead distribution network or if required underground cable; and
  - Grid power supply based on connection to existing electricity infrastructure will be provided as soon as possible but not later than from the third year onwards. In specific cases, power for the remote wellheads (up to 10% of total number of wells) will be generated locally by gas fired engines.
- Power requirements for Project facilities have changed:
  - CGPFs will have a 44 MW maximum power requirement, including power supplied to water treatment facilities, compared to 60 MW assessed in the EIS;
  - The maximum power demand for the largest FCF has increased from 19 MW assessed in the EIS to 30 MW for the SREIS; and
  - The maximum power demand for wellheads has decreased from 60 kW assessed in the EIS to 20 kW for the SREIS. Only production wells will require power.

- Changes to power generation equipment include:
  - A number of gas engines, with a capacity of 1.16 MW, are being considered to supply power to CGPFs and FCFs during the first two years of Project life. A 3 MW gas engine was assessed in the EIS; and
  - Multi-well pads share common surface infrastructure, including power supply. The SREIS assessment considers the same gas engines as those assessed in the EIS to supply power for remote multi-well pads (up to 10% of total production wells).
- Project flaring options have been changed:
  - There is no longer expected to be ramp-up flaring; and
  - Upset condition/operational flaring rates have been updated.

The locations of potentially affected receptors in the Project area have been identified in a desktop study. Approximately 286 potentially affected receptors have been identified in the Project area, shown in Figure 2-1. Since these locations were identified in a desktop study, the estimated number of receptors is considered to be conservative. During detailed design, ground-truthing of receptors in specific areas will be established.



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Projection: Geographic (GDA94)

Bowen Gas Project Tenements

Sensitive Receptor Point Location

Sensitive Receptor Built Up Area

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APPROXIMATE SENSITIVE RECEPTOR LOCATIONS

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Figure: **2-1**

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3 LEGISLATIVE CONTEXT

There have been no significant changes to the relevant noise and vibration related legislation since publication of the EIS. However, two of the Queensland Government's Guidelines in relation to environmental noise and vibration have been recently updated.

3.1 Legislation and Guidelines

The relevant noise and vibration legislation, standards and guidelines applicable to impact assessment in Queensland are as follows.

Noise

Queensland government publications that have been updated since the EIS include:

- The Queensland Department of Environment and Heritage Protection (EHP) Guideline "Noise Measurement Manual", Version 1 (August 2013); and
- The Queensland EHP Noise Assessment Guideline "Prescribing noise conditions for environmental authorities for petroleum activities", Version 2 (March 2013).

The noise monitoring procedures set out in the Noise Measurement Manual are consistent with the noise measurement methodology followed for the baseline noise measurements undertaken for the EIS. Hence the background noise measurements undertaken for the EIS are still valid for use in the Project assessment, and the results can still be considered current.

The Noise Assessment Guideline "Prescribing noise conditions for environmental authorities for petroleum activities" nominates noise conditions which are consistent with the Procedural Guide "Control of Noise from Gasfield Activities" (Rumble, 2011) upon which the noise conditions previously nominated in the EIS were based. Therefore the noise conditions nominated in the EIS are still valid and are compliant with the EHP's Noise Assessment Guideline published since the EIS.

Vibration

- Australian Standard AS 2670.2-1990 Evaluation of human exposure to whole-body vibration Part 2: Continuous and shock-induced vibration in building (1 to 80 Hz); and
- British Standard BS5228 Part 2, 2009. Code of Practice for Noise and Vibration Control on Construction and Open Sites.

There have been no updates to the project description regarding vibration, so vibration impacts have not been considered further in this assessment and the impact assessment undertaken in the EIS remains valid.

Blasting

- Queensland Government, 1994, *Environmental Protection Act 1994*; and
- Queensland Environmental Protection Agency, 2006, Ecoaccess Guideline: Noise and Vibration from Blasting.

There have been no updates to the project description regarding blasting, so blasting impacts have not been considered further in this assessment and the impact assessment undertaken in the EIS remains valid.

Road Traffic Noise

Queensland Department of Transport and Main Roads, Road Traffic Noise Management: Code of Practice, 2008.

4 STUDY APPROACH AND METHODOLOGY

The noise and vibration assessment has followed the same approach as the Noise and Vibration Technical Report (Appendix S) of the EIS. All relevant noise sources present on the site have been modelled using the same prediction methodologies and the same assumptions about the propagation of noise through the atmosphere.

4.1 Noise Modelling Methodology

Noise modelling has been undertaken using the proprietary noise modelling software SoundPlan version 7.3. Noise propagation calculations were undertaken using the CONCAWE predictive algorithm in the SoundPlan software with the following modelling parameters. The modelling parameters were chosen to be representative of worst-case meteorological conditions for noise propagation:

- Relative humidity: 70%
- Temperature: 20°C
- Wind Speed: 3.1 m/s
- Wind Direction: all
- Atmospheric Stability Class: D

Noise modelling was undertaken assuming flat ground topography and acoustically soft ground surface covering, except at the facilities where hard (acoustically reflective) ground surface covering was assumed.

5 ASSESSMENT OF POTENTIAL IMPACTS

5.1 Existing Environment

5.1.1 Existing Noise Levels

The existing noise levels in the study area are not expected to have changed since the EIS, therefore the background noise levels monitoring undertaken for the EIS is considered to still be valid.

5.1.2 Existing Vibration Sources

Existing sources of vibration in the Project area include several coal mines as well as several coal haulage railway lines.

There are multiple active mines consisting mostly of coal mines in the Bowen Basin within or near the Project area. Many of these mines would carry out blasting on almost a daily basis, which would be a regular source of vibration for sensitive receptors in the proximity.

The coal haulage railway lines that run through the Project area service many of these mines including Saraji and Peak Downs mines near Dysart, Blair Athol mine south-west of Moranbah, and the Goonyella mines north of Moranbah, as well as others. These railway lines would be regular sources of vibration for any receivers within close proximity such as some of the receptors in the town of Coppabella.

Other minor sources of vibration in the area include several highways including the Peak Downs highway which carries a relatively high volume of heavy vehicle traffic. Other roads that run through the Project area in proximity to sensitive receptors include Fitzroy Developmental Road, Middlemount Road and Suttor Developmental Road.

5.2 Construction Noise

The only significant change between the EIS and the SREIS as a result of the change in the project description is the addition of noise emissions from the possible introduction of a concrete batching plant, required for the Project, in the vicinity of the two CGPF sites.

A concrete batching plant may be required near the CGPF sites during the surface equipment installation phase of construction activities. Concrete would then be trucked to other sites as required.

The sound power level data used in the construction noise modelling predictions is provided in Appendix A of this report.

The revised noise emissions from the CGPF sites during the construction phase are shown in Table 5-1.

Table 5-1 Predicted construction noise levels - construction of CGPFs

Construction Stage	Equipment or Processes	Predicted Noise Level, dB(A)							
		50 m	100 m	150 m	200 m	250 m	500 m	750 m	1,000 m
Surface equipment installation	Bobcat	58	53	50	48	46	38	34	31
	Truck (50 tonne)	73	68	65	63	61	53	48	44
	Generator	71	66	63	61	59	52	48	44
	Air compressor	59	54	51	49	47	40	36	32
	Front end loader (37 kW)	72	68	64	62	60	53	48	45
	Concrete Batching Plant	73	67	62	58	55	48	44	40
	Total	**78**	**73**	**70**	**67**	**65**	**58**	**53**	**50**
Increase compared to EIS		**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**

The predicted noise levels shown in Table 5-1 show a minor increase of up to 1 dB(A) in the noise emissions during construction of a CGPF is expected due to the inclusion of a concrete batching plant.

As there have been no changes to the legislation or guidelines regarding noise from construction activities since production of the EIS, the recommendations for construction noise management given in the EIS remain valid.

5.3 Operational Noise

Because the exact locations of wells and facilities are not yet known, noise level predictions have been undertaken by modelling the noise levels received at several offset distances from the noise sources.

The operational noise level criteria was given in the Noise and Vibration Technical Report (Appendix S, Table 4-2) of the EIS. The relevant criterion for continuous noise sources is the minimum for the day, evening and night time periods which is 28 dB(A) $L_{Aeq,adj,15min}$.

5.3.1 Well Pads

The project description has updated the estimate of the number of wells to be drilled to a total of approximately 4,000. Their locations are not yet known so the noise assessment cannot undertake noise predictions at individual noise sensitive receptors, therefore noise level predictions have been presented at indicative distances up to 5 km from the noise sources.

The updated well pad design described in the revised project description incorporates two different types of wells on each well pad, and each well pad exists with its corresponding pair of wells located approximately 400 m away. Each production well intersects the corresponding lateral well which facilitates gas and water drainage to the production well. Only the production wells generate noise during operation. Therefore for a 4-well pad, only the two production wells generate noise, but for each pair of 4-well pads there will be a total of four production wells that generate noise. Similarly for each pair of 8-well pads there will be a total of eight production wells, and also for each pair of 12-well pads there will be 12 production wells. The pairs of well pads are nominally 400 m apart for each configuration. A general arrangement drawing of a pair of 4-well pads is shown in Figure 5-1. The alternative 8- or 12-well pads are similar designs but with more wells on each pad.

The noise source associated with each of the production wells is a 22 kW electric motor. The estimated sound power level of these motors used in the modelling is given in Appendix B of this report.

Noise from the changed configuration design of well pads since publication of the EIS has been predicted for each of the three pairs of well pad sizes:

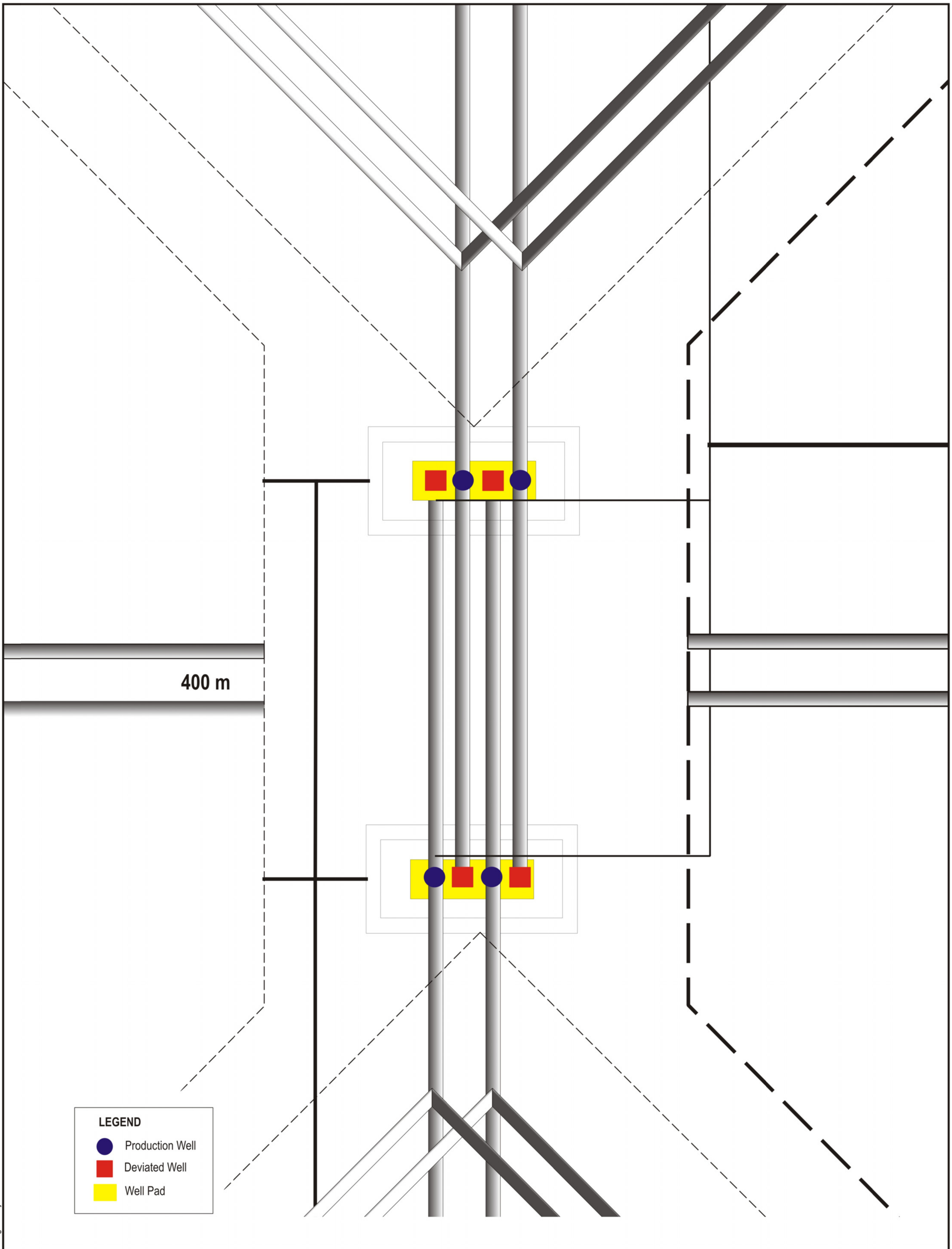
- 2 × 4 well pads;
- 2 × 8 well pads; and
- 2 × 12 well pads.

The nominated minimum distance of a well pad from a noise receptor is 300 m. However, since the well pad pairs are located approximately 400 m apart, depending on the orientation of the well pad pair the receptor may be as close as 300 m from both well pads, or as far as 700 m from one and 300 m from the other. For the purposes of this assessment, it has been assumed that the noise receptor is located at 300 m from both well pads.

The revised project description indicates that most of the production wells will be electrically driven, with power supplied from the electrical distribution network to be constructed along with the other Project infrastructure. It is estimated that between 90 to 98% of all wells will not require local power generation. Hence for the purposes of this impact assessment a conservative assumption of a maximum of 10% of wells not being electrically powered will be taken, and this 10% will require local power generation by small gas engines up to 60 kW in size. The predicted noise emissions from both the electrically driven wells and the well pads powered by on-site gas engines are given in Table 5-2 and shown in Appendix C of this report.

Table 5-2 Predicted noise levels from production wells

Well Pad Configuration	Noise Level dB(A)					Approx Distance Required to Achieve 28 dB(A)
Receptor Distance	300 m	1 km	2 km	3 km	4 km	(m)
2×4 Well Pads (electric)	32	18	9	< 10	< 10	350
2×8 Well Pads (electric)	34	21	12	< 10	< 10	460
2×12 Well Pads (electric)	34	23	14	< 10	< 10	500
2×4 Well Pads (gas engine powered)	35	21	13	< 10	< 10	500
2×8 Well Pads (gas engine powered)	37	24	16	10	< 10	620
2×12 Well Pads (gas engine powered)	36	25	17	11	< 10	620



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TYPICAL CONFIGURATION OF A PAIR OF 4-WELL PADS

As shown in Table 5-2 the noise emissions from all modelled well configurations may not comply with the limit of 28 dB(A) at the minimum distance of 300 m, and may require the inclusion of additional noise mitigation in order to achieve the criterion.

As also shown in Table 5-2 the predicted noise level limit of 28 dB(A) is achieved at various distances for the different well configurations without any additional noise mitigation being required, provided no other Project-related noise sources were contributing to the received noise.

Indicative noise level contour maps for the well configurations in Table 5-2 are provided in Figure-C-1 to Figure-C-6 in Appendix C of this report.

At distances less than 1 km, the noise limit can be achieved with an appropriate noise reduction strategy using a combination of distance attenuation and engineering noise control treatments.

5.3.2 Field Compression Facilities

FCFs will be comprised of a battery of screw compressors each producing nominally 20 TJ/d. FCFs will have up to seven compressor trains per facility, depending on the production capacity and the number of the connected wells. Their locations are not yet known so the noise assessment cannot present noise predictions at individual noise sensitive receptors. Therefore noise level predictions are presented at indicative distances up to 10 km from the noise sources.

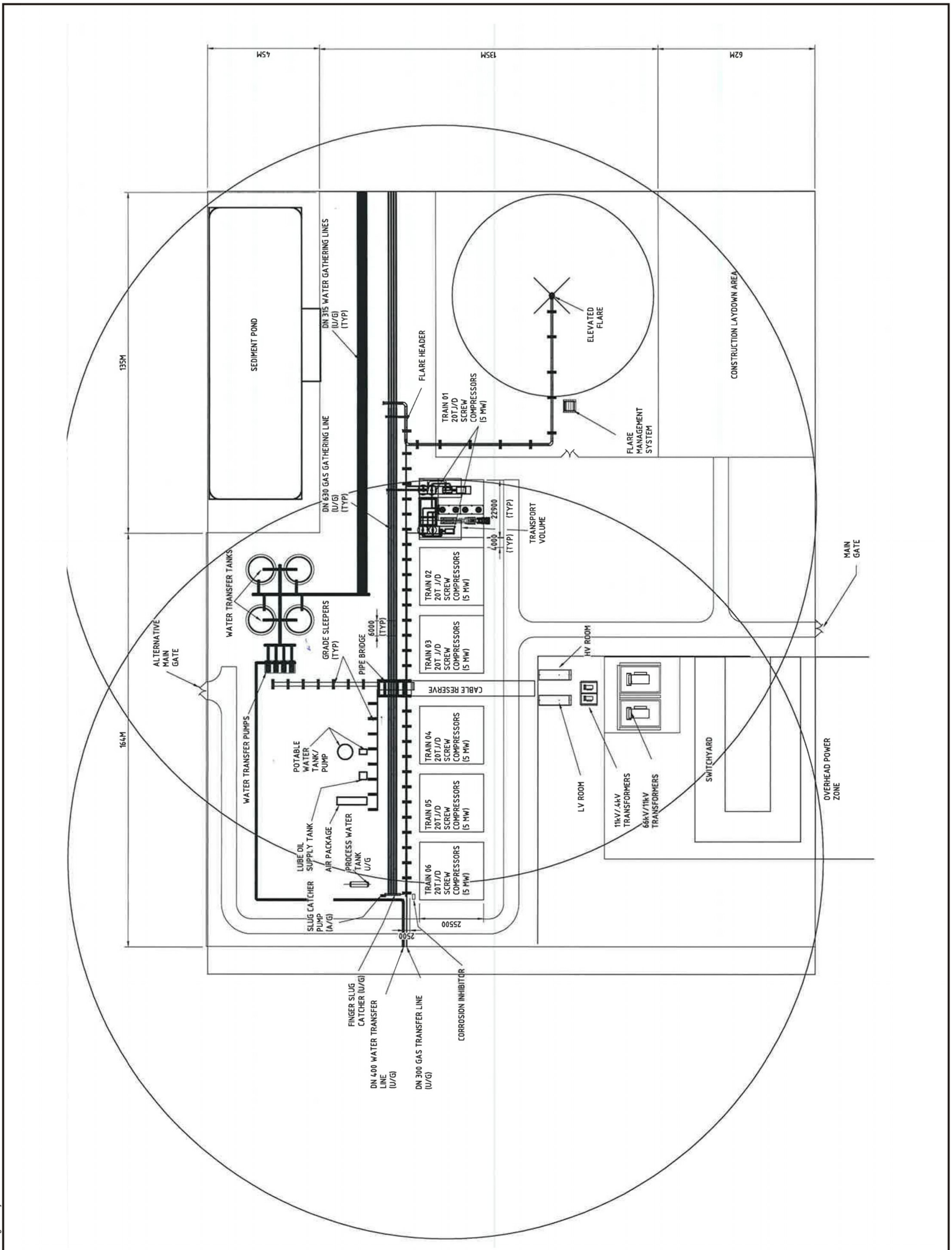
The expected total number of FCFs with the different number of compressor trains is given in Table 5-3.

Table 5-3 Number of FCFs with number of compressor trains

Number of compressor trains per FCF	Number of FCFs
1	3
2	9
3	13
4	4
5	1
6	2
7	1

The FCFs shown in Table 5-3 will be periodically commissioned between 2018 and 2031 with approximately half expected to commence operation in the first three years from 2018 to 2020. The mean, median and mode of the number of compression trains in each FCF are all 3.0 ± 0.05 so a detailed analysis of noise emissions has been undertaken for an FCF with three compression trains representing the most typical size of this type of facility. Noise level predictions have also been undertaken for an FCF with seven compressor trains representing the worst case for this type of facility. The noise emissions from an FCF will depend on the number of compressor trains.

A typical plant layout drawing of an FCF with six compressor trains is shown in Figure 5-2.



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TYPICAL LAYOUT OF A FIELD COMPRESSION FACILITY

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Figure: **5-2**

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All FCFs will ultimately be electrically powered from the power distribution network to be constructed with the other types of Project infrastructure. However, for up to the first two years in the interim during construction of the power distribution network a temporary power supply may be required at those FCFs planned to be commissioned during these initial two years. Two local temporary power generation options have been investigated. Local power generation can be undertaken with either temporary reciprocating gas engine generators (e.g. approximately 1.1 MW relocatable containerised reciprocating gas engines) or with small gas turbines (e.g. relocatable containerised open cycle gas turbines approximately 5.7 MW). These types of relocatable power generators are typically supplied with standard noise reduction treatments, although the noise control treatments can usually be upgraded if required.

The predicted noise levels from a 3-train and a 7-train FCF without additional noise mitigation are shown in Table 5-4 in kilometre interval distances from the facility. Noise level contour maps for the 3-train FCF with the alternative power supply options shown in Appendix C of this report.

The approximate distances that the different FCF configurations are predicted to comply with the 28 dB(A) noise limit without additional noise mitigation are shown in Table 5-4, provided no other Project-related noise sources are contributing to the received noise.

In order to achieve the noise limit criterion of 28 dB(A) at closer distances, noise mitigation treatments may be required for FCFs powered either electrically or by temporary power generation.

Indicative noise level contour maps for the FCF configurations in Table 5-2 are provided in Figure-C-7 to Figure-C-12 in Appendix C of this report.

Table 5-4 Predicted noise levels (dB(A)) from 3-train and 7-train FCFs without additional noise mitigation

FCF Noise Sources	Noise Level dB(A)					Approximate Distance Required to Achieve 28 dB(A)
Receptor Distance	1 km	2 km	3 km	4 km	5 km	(km)
FCF 3-Train (Electrically Powered)	55.5	40.2	30.2	23.3	18.3	3.2
FCF 3-Train (Powered - 1.1 MW Generators)	55.9	41.4	32.5	26.5	22.1	3.6
FCF 3-Train (Powered – 5.7 MW Generators)	55.5	40.4	30.7	24.1	19.3	3.8
FCF 7-Train (Electrically Powered)	58.4	43.4	33.5	26.7	21.7	3.8
FCF 7-Train (Powered - 1.1 MW Generators)	58.9	44.7	35.9	30	25.6	4.4
FCF 7-Train (Powered – 5.7 MW Generators)	59	45	36.5	30.6	26.1	4.6

5.3.2.1 Generator 7-train FCF with Electrical Power Supply

The component noise level contributions from the different types of noise sources present at the electrically powered 7-train FCF are shown in Table 5-5 at receiver distances of 1, 2, 3 and 4 km.

Table 5-5 Component noise level contributions from electrically powered 7-train FCF plant items without additional noise mitigation

No of Items	Noise Sources	1 km	2 km	3 km	4 km
14	2.6 MW Electric Motor	40	29	22	16
14	Cooler	44	34	28	23
7	Low Pressure Screw Compressors	55	39	28	20
7	High Pressure Screw Compressors	56	40	29	21
4	Water Transfer Pump + Motor	32	22	16	10
Total		**58**	**43**	**34**	**27**

As shown in Table 5-5 the dominant noise sources at the electrically powered FCF site are the compressors. The coolers and the electric drive motor also individually exceed the noise limit of 28 dB(A) at the 1 km receiver distance.

Note, the 7-train FCF is the largest of the FCFs of which there is only a single one out of the total 33. The average size of the FCFs is the 3-train FCF of which there are a total of 13.

5.3.2.2 7-train FCF with Temporary Local Power Generation

Two options have been investigated for temporary power supply of the FCFs in the interim if required before construction of the electrical distribution network has been completed.

The power options investigated were:

- A battery of reciprocating gas engines, approximately 1.1 MW each; and
- A battery of relocatable gas turbines, approximately 5.7 MW each.

Based on the power requirements for each of the FCF screw compressors, at least five of the 1.1 MW gas generators would be required per compressor train. If the power was provided by the alternative 5.7 MW gas turbines, one turbine would be required per compressor train.

The noise emissions from the relocatable power generators will add to the noise emissions from the FCFs received at the noise receptors. Therefore if an FCF is required to have local power generation, the combined predicted noise will need to be considered, and mitigation treatments may need to be applied to both so that the total noise can comply with the criteria.

7-train FCF with Battery of 1.1 MW Temporary Power Generators

The noise emissions from the temporary power plant comprised of 1.1 MW gas engines driving a 7-train FCF are shown in Table 5-6.

Table 5-6 Component noise levels from 1.1 MW temporary power generators at 7-train FCF

No of Items	Noise Sources	1 km	2 km	3 km	4 km
35	1.1 MW Generator - Cooler Fans	47	37	30	25
35	1.1 MW Generator Exhaust	44	34	27	23
35	1.1 MW Generator Mechanical	39	27	19	14
1.1 MW Generator Sub-total		**49**	**39**	**32**	**27**

As shown in Table 5-6, the component noise emissions from the 1.1 MW generators are predicted to exceed the noise limit criterion of 28 dB(A) at distances closer than 4 km without additional noise mitigation.

7-train FCF with Battery of 5.7 MW Temporary Power Generators

The noise emissions from the temporary power plant comprised of 5.7 MW gas engines driving a 7-train FCF are shown in Table 5-7.

Table 5-7 Component noise levels from 5.7 MW temporary power generators at 7-train FCF

No of Items	Noise Sources	1 km	2 km	3 km	4 km
7	5.7 MW Generator - Air Inlet	41	30	24	20
28	5.7 MW Generator - Cooler Fan	46	36	29	24
7	5.7 MW Generator - Exhaust	45	35	29	24
7	5.7 MW Generator - Lube Oil Cooler	35	25	18	14
7	5.7 MW Generator - Mechanical	41	30	24	18
5.7 MW Generator Sub-total		**50**	**40**	**33**	**28**

As shown in Table 5-7, the component noise emissions from the 5.7 MW generators are predicted to exceed the noise limit criterion of 28 dB(A) at distances closer than 4 km without additional noise mitigation.

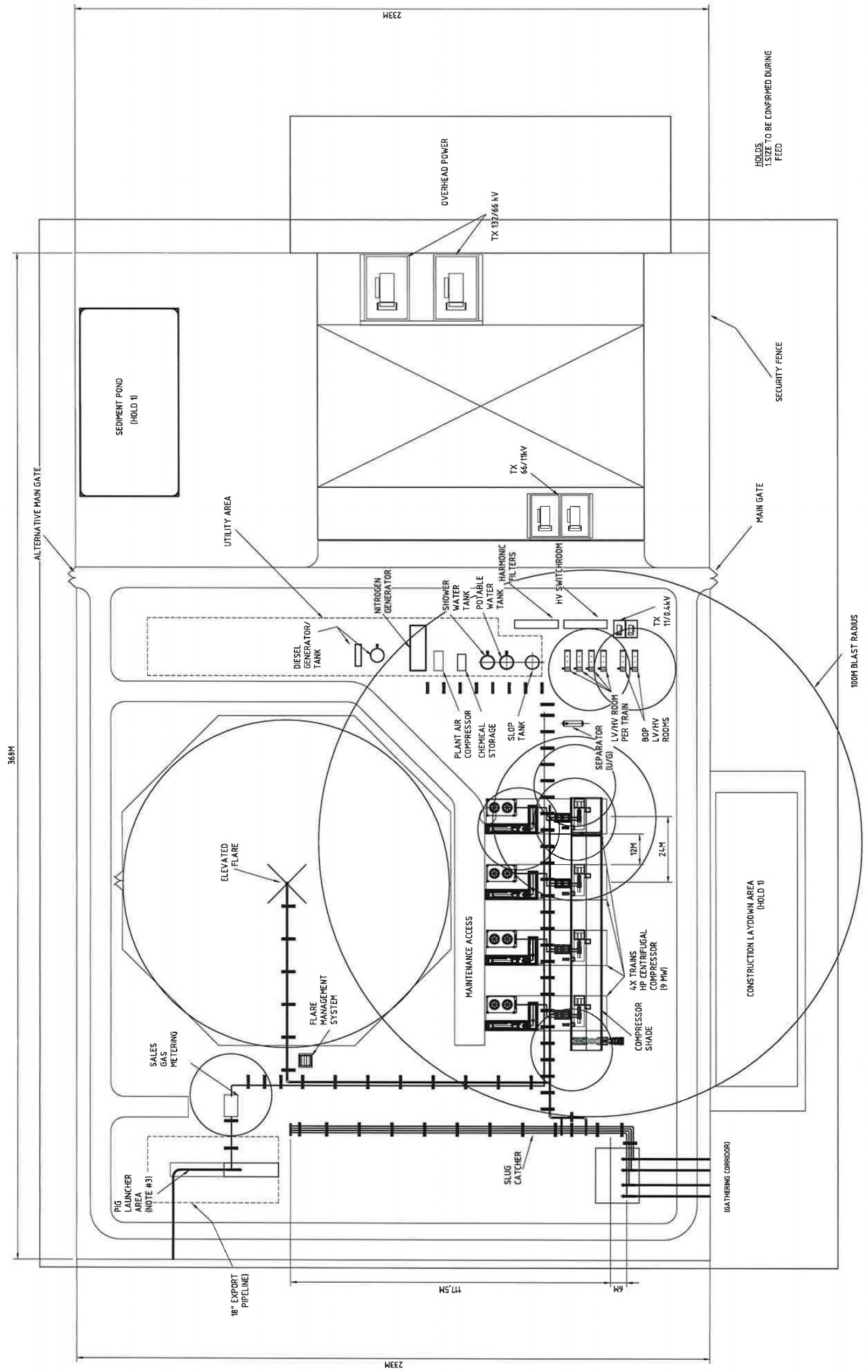
5.3.3 Central Gas Processing Facilities and Water Treatment Facilities

There are two CGPFs proposed as part of the Project. Their locations are not yet known so the noise assessment cannot undertake noise predictions at individual noise sensitive receptors, therefore noise level predictions have been presented at indicative distances up to 10 km from the noise sources.

The CGPFs will each be comprised of a battery of centrifugal compressors with each compressor train producing up to 90 TJ/d of gas. CGPF #1 will consist of five compressor trains producing 450 TJ/d and CGPF #2 will consist of four compressor trains producing 360 TJ/d.

A preliminary layout drawing of a CGPF is shown in Figure 5-3.

Predicted noise levels from CGPFs and the co-located WTFs without additional noise mitigation are shown in Table 5-8. Predicted noise level contour maps of a 5-train CGPF with alternative power supply options are shown in Appendix C of this report.



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BOWEN GAS PROJECT SREIS

TYPICAL LAYOUT OF A CENTRAL GAS PROCESSING FACILITY

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NOISE AND VIBRATION TECHNICAL REPORT

Figure: **5-3**

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Table 5-8 Predicted noise levels (dB(A)) from the 4-train and 5-train CGPFs and co-located WTFs without additional noise mitigation

CGPF Noise Sources	Noise Level dB(A)					Approximate Distance Required to Achieve 28 dB(A)
Receptor Distance	1 km	2 km	3 km	4 km	5 km	(km)
CGPF 4-Train (Electrically Powered)	50	40	33	27	22	3.9
CGPF 4-Train (Powered - 1.1 MW Generators)	52	42	35	30	26	4.8
CGPF 4-Train (Powered – 5.7 MW Generators)	53	43	36	31	27	4.9
CGPF 5-Train (Electrically Powered)	50	40	33	27	23	3.9
CGPF 5-Train (Powered - 1.1 MW Generators)	53	43	36	31	26	4.8
CGPF 5-Train (Powered – 5.7 MW Generators)	54	44	37	32	27	4.9

As shown in Table 5-8, both of the CGPFs are predicted to comply with the 28 dB(A) criterion at distances closer than 4 km when electrically powered. With either of the temporary power generation options, both of the CGPFs are predicted to comply with the 28 dB(A) criterion at distances closer than 5 km with temporary power generation. The approximate distances at which the noise limit of 28 dB(A) is predicted to be met for each configuration is shown in Table 5-8.

In order to achieve the noise limit criterion of 28 dB(A) at closer distances, noise mitigation treatments may be required for CGPFs powered either electrically or by temporary power generation.

Indicative noise level contour maps for the 5-train CGPF configurations in Table 5-2 are provided in Figure-C-13 to Figure-C-15 in Appendix C of this report.

5.3.3.1 CGPF with Electrical Power Supply

The component noise level contributions from the different types of noise sources present at the electrically powered 5-train CGPF are shown in Table 5-9 at receiver distances of 1, 2, 3 and 4 km.

Table 5-9 Component noise level contributions from electrically powered 5-train CGPF plant items without additional noise mitigation

Number of items	Noise Sources	1 km	2 km	3 km	4 km
CGPF					
5	CGPF 9 MW Electric Motors	39	29	22	16
5	CGPF Cooler	39	28	22	17
5	CGPF Centrifugal Compressors	44	31	23	17
CGPF Sub-total		**46**	**34**	**27**	**21**

Number of items	Noise Sources	1 km	2 km	3 km	4 km
WTF					
24	WTF Pressure Control Valves	31	21	14	8
25	WTF 55 kW Centrifugal Pumps	37	28	21	15
25	WTF 55 kW Electric Motors	44	35	28	22
10	WTF 110 kW Centrifugal Pumps	37	27	20	15
10	WTF 110 kW Electric Motors	43	34	27	21
8	WTF 315 kW Centrifugal Pumps	34	24	17	11
8	WTF 315 kW Electric Motors	31	21	15	9
WTF Sub-total		**48**	**38**	**32**	**26**
CGPF + WTF TOTAL		**50**	**40**	**33**	**27**

As shown in Table 5-9 the noise sources associated with the WTF are responsible for higher noise levels at the receivers than the noise sources of the CGPF. The highest of the contributing WTF noise sources are the electric motors and the loudest of the CGPF noise sources are the compressors.

5.3.3.2 CGPF with Temporary Local Power Generation

Two options have been investigated for temporary power supply of the CGPFs in the interim before construction of the electrical distribution network has been completed. The options were investigated for the 5-train CGPF as it would be a marginally more conservative analysis.

The power options investigated were:

- A battery of reciprocating gas engines, approximately 1.1 MW each; and
- A battery of relocatable gas turbines, approximately 5.7 MW each.

Based on the power requirements for each of the CGPF centrifugal compressors, at least eight of the 1.1 MW gas engine generators would be required per compressor train. If the power was provided by the alternative 5.7 MW gas turbines, two turbines would be required per compressor train.

The noise emissions from the relocatable power generators will add to the noise emissions from the CGPF received at the noise receptors. Therefore if a CGPF is required to have local power generation, the combined noise from both plant will need to be considered, and mitigation treatments may need to be applied to both so that the total noise can comply with the criteria.

CGPF with Battery of 1.1 MW Temporary Power Generators

The noise emissions from the temporary power plant comprised of 1.1 MW gas engine generators to power a 5-train CGPF are shown in Table 5-10.

Table 5-10 Component noise levels from 1.1 MW temporary power generators at 5-train CGPF

No of Items	Noise Sources	1 km	2 km	3 km	4 km
40	1.1 MW Generator - Cooler Fans	**40**	**30**	**24**	**20**
40	1.1 MW Generator Exhaust	**39**	**29**	**23**	**19**
40	1.1 MW Mechanical	**35**	**23**	**18**	**15**
1.1 MW Generator Sub-total		**43**	**41**	**27**	**23**

As shown in Table 5-10, the component noise emissions from the 1.1 MW generators are predicted to exceed the noise limit criterion of 28 dB(A) at distances closer than 4 km without additional noise mitigation.

CGPF with Battery of 5.7 MW Temporary Power Generators

The noise emissions from the temporary power plant comprised of 5.7 MW gas turbines powering a 5-train CGPF are shown in Table 5-11.

Table 5-11 Component noise levels from 5.7 MW temporary power generators at 5-train CGPF

No of Items	Noise Sources	1 km	2 km	3 km	4 km	5 km
10	Air Inlets	38	32	26	21	18
40	Cooler Fans	44	37	31	26	23
10	Exhausts	42	37	30	25	21
10	Lube Oil Coolers	34	26	21	17	14
10	Mechanical	40	32	25	20	16
5.7 MW Generator Sub-total		**48**	**41**	**35**	**30**	**27**

As shown in Table 5-11, the component noise emissions from the 5.7 MW generators are predicted to exceed the noise limit criterion of 28 dB(A) at distances closer than 5 km without additional noise mitigation.

5.3.4 Flaring

5.3.4.1 Ramp-up Flaring

Arrow advised that in an effort to reduce gas flaring, it will minimise flaring associated with the upstream Project ramp-up. Based on the timing of the Surat Gas Project (with the first Arrow Liquefied Natural Gas Train) and the Arrow Bowen Pipeline Project, the Bowen Gas Project commissioning strategy looks to use gas from the Arrow Bowen Pipeline, backfilled from the Gladstone Gas Hub, for commissioning of wells, FCFs and CGPFs. This negates the need to use gas from the Project wells for commissioning of the wells, FCFs and CGPFs, and minimises the possibility of excess gas being flared during commissioning of the upstream facilities. Therefore, under this current design concept, limited or no ramp-up flaring is expected to take place in any gas field or at any compression facility.

5.3.4.2 *Upset Condition / Maintenance Flaring*

Flaring at FCFs and CGPFs may occur due to upset conditions throughout the operational phase of the Project.

Worst-case unplanned and planned maintenance flaring frequency and rates at FCFs were updated as follows:

- Approximately one occurrence in 5 years at a rate of 40 TJ/d for 13 hours; and
- Approximately 10 occurrences per year at a rate of 20 TJ/d for 26 hours.

Worst-case unplanned and planned maintenance flaring frequency and rates at CGPFs were updated as follows:

- Approximately one occurrence in 2 years at a rate of 360 TJ/d for 21 hours;
- Approximately one occurrence in 5 years at a rate of 141 TJ/d for 22 hours;
- Approximately one occurrence in 3 years at a rate of 62 TJ/d for 18 hours; and
- Approximately 12 occurrences per year at a rate of 30 TJ/d for 41 hours.

As the expected durations of these flaring events are between 8 hours and 5 days, and they are not expected to occur at intervals less than four weeks, flaring associated with the Project would be defined as medium-term events according to the *PGA Noise Guideline*.

Flares at FCFs

Noise emissions have been predicted from the flares that will be located at the FCFs with estimated potential flaring rates of 20 and 40 TJ/d.

The predicted noise levels from flaring at a 3-train and a 7-train FCF are shown in Table 5-12 in kilometre interval distances from the facility.

Table 5-12 Predicted component noise levels (dB(A)) from flaring at 3-train and 7-train FCFs

Distance	20 TJ/d (approx. 10 per year)	40 TJ/d (approx. 1 per 5 years)
1 km	33	36
2 km	20	23
3 km	13	16
4 km	< 10	11
5 km	< 10	< 10

Flares at CGPFs

The sound power levels of noise emissions from the CGPF flaring operations were estimated using a combination of the methods given in ISO 23251-2006 “Petroleum, petrochemical and natural gas industries -- Pressure-relieving and depressuring systems” and VDI 3732:1999 “Standard Noise Levels of Technical Sound Sources – Flares”.

For each of the different flaring rates, the overall sound power level in dB(A) was estimated using ISO 23251-2006 and the octave band frequency spectral shape was estimated using VDI 3732-1999.

The results of the noise modelling of flaring at the CGPFs are given in Table 5-13.

Table 5-13 Flaring at CGPFs dB(A)

Receiver	360 TJ/d (80 kg/s) (approx. 1 per 2 years)	141 TJ/d (31 kg/s) (approx. 1 per 5 years)	62 TJ/d (14 kg/s) (approx. 1 per 3 years)	30 TJ/d (7 kg/s) (approx. 12 per year)
1 km	65	61	58	55
2 km	55	51	47	44
3 km	48	44	40	37
4 km	42	38	35	32
5 km	38	34	31	28
6 km	35	30	27	24
7 km	32	27	24	21
8 km	29	25	21	18
9 km	27	23	19	16
10 km	25	21	18	15

As shown in Table 5-13, noise emissions from flaring may exceed the medium-term noise criterion of 28 dB(A) at distances about up to 8 km from the flare, depending on the flaring rate.

The three flare events generating the highest noise levels are expected to occur only rarely (between 2 to 5 years). The lowest expected flaring rate of 30 TJ/d is expected to occur approximately 12 times per year for approximately 41 hours. On these occasions, flaring noise is expected to exceed the medium-term night-time criteria at distances approximately up to 5 km.

5.4 Noise Impact on Protected Areas and Fauna

A discussion and assessment of potential noise impacts on any nearby protected areas, terrestrial or avifauna is provided in the Terrestrial Ecology Technical Report (Appendix P, Section 6.6.4) of the EIS.

The Terrestrial Ecology Technical Report (Appendix P, Table 19) of the EIS lists 24-hour noise from gas facility operation and maintenance as an activity component that threatens ecological values, where the potential impact is to cause animals to leave the area.

The protected areas such as National Parks and Refuges are listed in the Terrestrial Ecology Technical Report (Appendix P, Section 5.4) of the EIS.

The predicted noise levels in this noise impact assessment report may be used as a guide to determine the extent of noise impact in the listed protected areas, which can assist the selection of suitable sites for large gas processing facilities.

5.5 Road Traffic Noise

Changes to the project description have resulted in minor revisions to the estimated traffic volumes related to construction of the facilities.

Changes to the expected number of heavy vehicle trips per facility and the expected activity duration of facilities' construction results in slightly higher or lower numbers of average vehicle movements per facility.

Table 5-14 Traffic generation during facility construction

Activity	Number of heavy vehicles (per site)	Duration	Vehicles per day (average)
Production wells	232	67 days	3
FCF	1516	26 weeks	8
CGPF	2858	52 weeks	8
WTF	9126	52 weeks	25

As shown in Table 5-14 the average traffic generation during facility construction will add very few heavy vehicles to the existing public roads.

Similarly to the conclusions of the EIS noise and vibration impact assessment, the increases in traffic on public roads will have a negligible increase in noise level at the nearest receivers when assessed as an $L_{A10,18hr}$.

6 NOISE IMPACT MITIGATION MEASURES

6.1 Mitigation Packages for Gas Facilities and Water Treatment Facilities

Mitigation packages have been considered to reduce the setback distance required to achieve the Project noise criteria. The mitigation packages investigated were the same as previously considered in the EIS. The assumed acoustic attenuation properties of the various mitigation treatments are reproduced in Appendix D of this report.

The noise reduction performance of the treatments shown in Appendix D of this report have been modelled as an approximate Insertion Loss representing a total reduction in sound power level of noise sources with no detail of sound directivity included. In practice the noise emissions of complex machinery are focussed in certain directions and this needs to be taken into account during the detailed design phase.

6.2 Well Pads

6.2.1 Electrically Powered Well Pads

Noise mitigation for well pads can be achieved using either acoustic enclosures over the electric motors and/or construction of a noise barrier in close proximity to the motors. For the electrically powered well pads, noise mitigation of 4 to 6 dB(A) may be required to achieve the noise limit criterion of 28 dB(A) at a receiver 300 m away, provided no other Project related noise sources were contributing to the received noise. This level of noise attenuation could be achieved by an acoustic enclosure with at least the noise reduction performance of Enclosure Package 1 (refer Appendix D of this report) or with a noise barrier. To be effective, the noise barrier would need to be at least 2 m higher than the top of the noise source (electric motor) and no further than a distance of 5 m.

6.2.2 Well Pads with Local Power Generation

An additional 9 dB(A) noise attenuation would be required in order to achieve the noise criterion of 28 dB(A) at 300 m from a well pad. Noise mitigation for the electric motors at the well pads can be achieved using acoustic enclosures. However the gas engines are already enclosed in a noise attenuation casing, so the noise emissions from these generators cannot be easily improved by a substantial margin. As the generator's cooling air outlet and exhaust can be relatively high above ground level (typically between 3 and 4 m) the noise barrier wall would need to be at least 6 m tall to achieve substantial noise attenuation. To be effective, the noise barrier would need to be at least 2 m higher than the top of the noise source (exhaust / cooling air outlet) and no further than a distance of 5 m.

6.3 FCFs

Acoustics treatment package selections have been investigated to determine if noise emissions from a 7-train FCF can comply with the noise limit criterion at various distances and what types of noise treatments might be required. Noise attenuation details for the acoustic treatment packages are given in Appendix D of this report.

Similar noise mitigation investigations would be undertaken for each of the FCFs with various numbers of compressor trains during the detailed design phase when the final detailed plant and equipment noise emission information is available.

6.3.1 Mitigation of 7-Train FCFs Powered by Electrical Distribution Network

The acoustics treatment package selections for a 7-train electrically powered FCF are presented in Table 6-1.

Table 6-1 Acoustics treatment package selections and resultant noise levels – electrically powered 7-train FCFs

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
2.6 MW Electric motors	Enclosure Package 2	Enclosure Package 1		-
Coolers	Cooler Package 4	Cooler Package 2	Cooler Package 1	-
LP Screw compressors	Enclosure Package 3	Enclosure Package 1	Enclosure Package 1	-
HP Screw Compressors	Enclosure Package 3	Enclosure Package 1	Enclosure Package 1	-
Water Transfer Pumps and Motors	Enclosure Package 1			-
Resultant noise level dB(A)	**27**	**27**	**27**	**27**

Note: Acoustics treatment package details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 3: Sealed steel enclosure with 1 mm sheet thickness, lined with 50 mm thick sound absorbing material, and 900 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 1: Medium-grade cooler silencers.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with variable fan drive (VFD) and high-grade cooler silencers.

As shown in Table 6-1, the proposed acoustic treatments applied to individual noise sources are predicted to achieve the noise limit criterion at the distances shown, provided no other Project-related noise source contributes to the noise level at the receiver.

As shown in Appendix E, Figure-E-1 of this report, the 28 dB(A) noise contour representing the noise limit is predicted at approximately 1 km from the plant with the above selection of noise mitigation treatments, for the case where the nearest receptor is located 1 km from the plant.

For the case of FCFs powered by temporary power generators in the interim before the electrical distribution network is completed, the additional noise produced by the generators needs to be considered as well.

6.3.2 Mitigation of 7-Train FCFs Powered by Battery of 1.1 MW Generators

With the presence of the generators contributing to the noise emissions, the required noise treatments on the FCF components would need to be improved above the amount required for an electrically powered FCF so that the total plant noise emissions can achieve the criteria.

Further noise reduction can be achieved for the FCFs' gas plant by incorporating more effective noise reduction treatments. However the gas engines of the 1.1 MW generators are already enclosed in a noise attenuation casing, so the noise emissions from these generators cannot be easily improved by a substantial margin only by improving the enclosure. Instead, it would likely be necessary to achieve the required noise attenuation using a combination of distance attenuation and noise barriers. As the generator's exhaust can be relatively high above ground level (typically between 3 and 4 m) the noise barrier wall would need to be several metres taller than this to achieve substantial noise attenuation. To be effective, the noise barrier would need to be at least 3 m higher than the top of the generator and no further than a distance of 5 m.

Significant noise reduction can usually be achieved with acoustic shielding by noise barriers such as solid walls or earth berms, however the practically achievable attenuation of noise barriers is limited to about 10 to 15 dB(A). With the combined noise of the generators and the FCF gas plant, the total noise from the facility may not be able to achieve the noise limit criterion of 28 dB(A) up to distances between 2 to 3 km.

Table 6-2 shows the noise treatments for a 7-train FCF powered by 1.1 MW gas engine generators required to meet the noise limit criterion of 28 dB(A) at various distances.

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Table 6-2 Acoustics treatment package selections and resultant noise levels – 1.1 MW gas engine powered 7-train FCFs

Noise sources	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
FCF				
2.6 MW Electric motors	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
Coolers	Cooler Package 4	Cooler Package 3	Cooler Package 2	Cooler Package 1
LP Screw compressors	Enclosure Package 4	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
HP Screw Compressors	Enclosure Package 4	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
Water Transfer Pumps & Motors	Enclosure Package 2	Enclosure Package 1		
Sub-total FCF dB(A)	**26**	**25**	**21**	**22**
1.1 MW Generators				
Coolers	Cooler Package 4	Cooler Package 4	Cooler Package 2	Cooler Package 2
Exhaust	High-Grade Muffler	High-Grade Muffler	High-Grade Muffler	Medium-Grade Muffler
Mechanical	10 m Noise Barrier	10 m Noise Barrier		
Sub-total Generators dB(A)	**37**	**27**	**24**	**25**
TOTAL FCF + Generators	**38**	**29**	**26**	**27**

Note: Acoustics treatment packages details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 4: Sealed steel enclosure with 1.6 mm sheet thickness, lined with 75 mm thick sound absorbing material, and 1500 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 1: Medium-grade cooler silencers.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 3: Fan with VFD and high-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with VFD and high-grade cooler silencers.
- Muffler: Low-grade, medium-grade or high-grade mufflers.

As shown in Table 6-2, it is unlikely that the noise limit of 28 dB(A) can be achieved at 2 km from the FCF while the temporary power generators are on site, even with very high performance noise control treatments applied to the dominant noise sources.

The predictions indicate that the noise criteria can likely be met at 3 km distance with high performance noise attenuation treatments, provided no other noise from Project-related equipment is contributing at the receptor location.

As shown in Appendix E, Figure-E-2 of this report, the 28 dB(A) noise contour representing the noise limit is predicted at approximately 2.7 km from the plant with the above selection of noise mitigation treatments, for the case where the nearest receptor is located 3 km from the plant.

6.3.3 Mitigation of FCFs Powered by Battery of 5.7 MW Generators

With the presence of the generators contributing to the noise emissions, the required noise treatments on the FCF components would need to be improved above the amount required for an electrically powered FCF so that the total plant noise emissions can achieve the criteria.

Further noise reduction can be achieved for the FCF gas plants by incorporating more effective noise reduction treatments. However the gas turbines are already enclosed in a noise attenuation casing, so the noise emissions from these generators cannot be easily improved by a substantial margin only by improving the enclosure. Instead, it would likely be necessary to achieve required noise attenuation using a combination of distance attenuation and noise barriers. As the generator’s air inlet and exhaust can be relatively high above ground level the noise barrier wall would need to be several metres taller than this to achieve substantial noise attenuation. To be effective, the noise barrier would need to be at least 3 m higher than the top of the noise source (exhaust/cooling air outlet) and no further than 5 m distance.

Significant noise reduction can usually be achieved with acoustic shielding by noise barriers such as solid walls or earth berms, however the practically achievable attenuation of noise barriers is limited to about 10 to 15 dB(A). With the combined noise of the generators and the FCF gas plant, the total noise from the facility may not be able to achieve the noise limit criterion of 28 dB(A) at distances less than 2 km.

Table 6-3 shows the noise treatments for a 7-train FCF powered by 5.7 MW gas turbines with the aim of meeting the noise limit criterion of 28 dB(A) at various distances.

Table 6-3 Acoustics treatment package selections and resultant noise levels – 5.7 MW gas turbine powered 7-train FCFs

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
FCF				
2.6 MW Electric motors	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
Coolers (2 fans, inlet plus outlet)	Cooler Package 4	Cooler Package 3	Cooler Package 2	Cooler Package 1
LP Screw compressors	Enclosure Package 3	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
HP Screw Compressors	Enclosure Package 3	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
Water Transfer Pump & Motors	Enclosure Package 1	Enclosure Package 1		
Sub-total FCF dB(A)	**26**	**25**	**21**	**22**
5.7 MW Generators				
Air Inlet	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (Medium-Grade)
Cooler Fan	Cooler Package 4	Cooler Package 2	Cooler Package 3	Cooler Package 1
Exhaust	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (High-Grade)	
Lube Oil Cooler	Cooler Package 3	Cooler Package 2	Cooler Package 1	
Mechanical	10m barrier			
Sub-total Generator dB(A)	**39**	**30**	**26**	**24**
TOTAL FCF + Generators	**39**	**31**	**27**	**26**

Note: Acoustics treatment packages details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 3: Sealed steel enclosure with 1 mm sheet thickness, lined with 50 mm thick sound absorbing material, and 900 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 1: Medium-grade cooler silencers.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 3: Fan with VFD and high-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with VFD and high-grade cooler silencers.
- Muffler: Low-grade, medium-grade or high-grade mufflers.

As shown in Table 6-3, it is unlikely that the noise limit of 28 dB(A) can be achieved at 2 km from the FCF while the temporary power generators are on site, even with very high performance noise control treatments applied to the dominant noise sources.

The predictions indicate that the noise criteria can likely be met at 3 km distance with very high performance noise attenuation treatments, provided no other noise from Project-related equipment is contributing at the receptor location.

As shown in Appendix E, Figure-E-3 of this report, the 28 dB(A) noise contour representing the noise limit is predicted at approximately 2.7 km from the plant with the above selection of noise mitigation treatments, for the case where the nearest receptor is located 3 km from the plant.

6.4 CGPFs

Acoustics treatment package selections have been investigated to determine if noise emissions from a 5-train CGPF can comply with the noise limit criterion at various distances and what types of treatments might be required. The acoustics treatment package selections for a 5-train electrically powered CGPF are presented in Table 6-4. Noise attenuation details for the acoustic treatment packages are given in Appendix D of this report.

Similar noise mitigation investigations would be undertaken for both of the CGPFs during the detailed design phase when the final detailed plant and equipment noise emission information is available.

6.4.1 Mitigation of CGPFs Powered by Electricity Distribution Network

The acoustics treatment package selections for a 5-train electrically powered CGPF are presented in Table 6-4.

Table 6-4 Acoustics treatment package selections– electrically powered 5-train CGPFs

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
CGPF				
9 MW Electric Motor	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
Cooler	Cooler Package 4	Cooler Package 2	Cooler Package 1	-
Centrifugal Compressor	Enclosure Package 4	Enclosure Package 1	Enclosure Package 1	-
Sub-total CGPF dB(A)	**22**	**21**	**19**	**22**
WTF				
Pressure Control Valves	Enclosure Package 1	Enclosure Package 1	-	-
55 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	-	-
55 kW Electric Motor	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
110 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	-	-

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
110 kW Electric Motors	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
315 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	-	-
315 kW Electric Motors	Enclosure Package 1	Enclosure Package 1	-	-
Sub-total WTF dB(A)	**26**	**25**	**26**	**24**
TOTAL CGPF + WTF dB(A)	**27**	**26**	**27**	**26**

Note: Acoustics treatment packages details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 4: Sealed steel enclosure with 1.6 mm sheet thickness, lined with 75 mm thick sound absorbing material, and 1,500 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 1: Medium-grade cooler silencers.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with VFD and high-grade cooler silencers.
- Muffler: Low-grade, medium-grade or high-grade mufflers.

As shown in Table 6-4, it is expected that the noise level limit of 28 dB(A) is achievable at 1 km distance from the plant with very high-performance noise attenuation treatments applied to the CGPF and high performance treatments to the WTF noise sources, provided no other noise from Project-related equipment is contributing at the receptor location.

The results in Table 6-4 also show that the noise limit can be achieved at 2 km distance with moderate acoustic attenuation treatments applied to all plant.

Indicative noise level contours are given in Appendix E, Figure-E-4 for the electrically powered 5-train CGPF with noise mitigation implemented for the case of a noise receiver located at 1 km from the plant.

6.4.2 *Mitigation of CGPFs Powered by Battery of 1.1 MW Generators*

With the presence of the generators contributing to the noise emissions, the required noise treatments on the CGPF components would need to be improved above the amount required for an electrically powered CGPF so that the total plant noise emissions can achieve the criteria.

Further noise reduction can be achieved for the CGPFs' gas plant by incorporating more effective noise reduction treatments. However the gas engines of the 1.1 MW generators are already enclosed in a noise attenuation casing, so the noise emissions from these generators cannot be easily improved by a substantial margin only by improving the enclosure. Instead, it would likely be necessary to achieve the required noise attenuation using a combination of distance attenuation and noise barriers. As the generators' exhausts can be relatively high above ground level (typically between 3 and 4 m) the noise barrier wall would need to be several metres taller than this to achieve substantial noise attenuation. To be effective, the noise barrier would need to be at least 3 m higher than the top of the generator and no further than 5 m distance.

Significant noise reduction can usually be achieved with acoustic shielding by noise barriers such as solid walls or earth berms, however the practically achievable attenuation of noise barriers is limited to about 10 to 15 dB(A). With the combined noise of the generators and the CGPF gas plant, the total noise from the facility may not be able to achieve the noise limit criterion of 28 dB(A) at distances less than 2.7 km.

Table 6-5 shows the noise treatments for a 5-train CGPF powered by 1.1 MW gas engines with the aim of meeting the noise limit criterion of 28 dB(A) at various distances.

Table 6-5 Acoustics treatment package selections and resultant noise levels – 1.1 MW gas engine powered 5-train CGPFs

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
CGPF				
9 MW Electric Motor	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
Cooler	Cooler Package 4	Cooler Package 2	Cooler Package 1	-
Centrifugal Compressor	Enclosure Package 4	Enclosure Package 1	Enclosure Package 1	-
Sub-total CGPF dB(A)	**22**	**21**	**19**	**22**
WTF				
Pressure Control Valves	Enclosure Package 1	Enclosure Package 1	-	-
55 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
55 kW Electric Motor	Enclosure Package 3	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1
110 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	-
110 kW Electric Motors	Enclosure Package 3	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1
315 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 2	Enclosure Package 1	-
315 kW Electric Motors	Enclosure Package 1	Enclosure Package 1	-	-
Sub-total WTF dB(A)	**23**	**20**	**21**	**21**

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
1.1 MW Generators				
Coolers	Cooler Package 4	Cooler Package 3	Cooler Package 2	Cooler Package 2
Exhaust	High-Grade Muffler	High-Grade Muffler	Medium-Grade Muffler	Medium-Grade Muffler
Mechanical Noise	10 m Noise Barrier			
Sub-total 1.1 MW Gens dB(A)	**38**	**31**	**24**	**23**
TOTAL CGPF + WTF + 1.1 MW Gens dB(A)	**38**	**31**	**27**	**27**

Note: Acoustics treatment packages details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 3: Sealed steel enclosure with 1 mm sheet thickness, lined with 50 mm thick sound absorbing material, and 900 mm long (33%) splitter attenuators at inlet and discharge.
- Enclosure Package 4: Sealed steel enclosure with 1.6 mm sheet thickness, lined with 75 mm thick sound absorbing material, and 1500 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 3: Fan with VFD and high-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with VFD and high-grade cooler silencers.
- Muffler: Low-grade, medium-grade or high-grade mufflers.

As shown in Table 6-5, it is unlikely that the noise limit of 28 dB(A) can be achieved at distances of 2 km or less from the CGPF while the temporary power generators are on site, even with very high performance noise control treatments applied to the dominant noise sources.

The predictions indicate that the noise criteria can likely be met at 3 km distance with moderate performance noise attenuation treatments, provided no other noise from Project-related equipment is contributing at the receptor location.

Indicative noise level contours are provided in Appendix E, Figure-E-5 of this report for the 5-train CGPF powered by 1.1 MW gas engine generators with noise mitigation implemented with the aim of achieving the noise limit at 3 km from the plant. With the selected noise treatments, the 28 dB(A) noise contour is predicted at approximately 2.7 km from the CGPF plant.

6.4.3 Mitigation of CGPFs Powered by Battery of 5.7 MW Generators

With the presence of the generators contributing to the noise emissions, the required noise treatments on the CGPF components would need to be improved above the amount required for an electrically powered CGPF so that the total plant noise emissions can achieve the criteria.

Further noise reduction can be achieved for the CGPFs' gas plant by incorporating more effective noise reduction treatments. However the gas turbines of the 5.7 MW generators are already enclosed in a noise attenuation casing, so the noise emissions from these generators cannot be easily improved by a substantial margin only by improving the enclosure. Instead, it would likely be necessary to achieve the required noise attenuation using a combination of distance attenuation and noise barriers. As the generators' exhausts can be relatively high above ground level (typically between 3 and 4 m) the noise barrier wall would need to be several metres taller than this to achieve substantial noise attenuation. To be effective, the noise barrier would need to be at least 3 m higher than the top of the generator and no further than 5 m distance.

Significant noise reduction can usually be achieved with acoustic shielding by noise barriers such as solid walls or earth berms, however the practically achievable attenuation of noise barriers is limited to about 10 to 15 dB(A). With the combined noise of the generators and the CGPF gas plant, the total noise from the facility may not be able to achieve the noise limit criterion of 28 dB(A) at distances less than 2 km.

Table 6-6 shows the noise treatments for a 5-train CGPF powered by 5.7 MW gas turbines with the aim of meeting the noise limit criterion of 28 dB(A) at various distances.

Table 6-6 Acoustics treatment package selections and resultant noise levels – 5.7 MW gas turbine powered 5-train CGPFs

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
CGPF				
9 MW Electric Motor	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	
Cooler	Cooler Package 4	Cooler Package 2	Cooler Package 1	
Centrifugal Compressor	Enclosure Package 4	Enclosure Package 1	Enclosure Package 1	
Sub-total CGPF dB(A)	**22**	**21**	**19**	**22**
WTF				
Pressure Control Valves	Enclosure Package 1	Enclosure Package 1		
55 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 2	Enclosure Package 1	
55 kW Electric Motor	Enclosure Package 3	Enclosure Package 1	Enclosure Package 1	Enclosure Package 1
110 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	
110 kW Electric Motors	Enclosure Package 3	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1
315 kW Centrifugal Pumps	Enclosure Package 2	Enclosure Package 1	Enclosure Package 1	

Noise source	Distance from source to nearest receptor			
	1 km	2 km	3 km	4 km
315 kW Electric Motors	Enclosure Package 1	Enclosure Package 1		
Sub-total WTF dB(A)	**23**	**20**	**21**	**21**
5.7 MW Generators				
Air Inlet	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (Medium-Grade)
Cooler Fan	Cooler Package 4	Cooler Package 4	Cooler Package 3	Cooler Package 2
Exhaust	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (High-Grade)	Muffler (Medium-Grade)
Lube Oil Cooler	Cooler Package 4	Cooler Package 2	Cooler Package 2	
Mechanical	10m barrier	10m barrier		
Sub-total 5.7 MW Gens dB(A)	**34**	**30**	**27**	**26**
TOTAL CGPF + WTF + 5.7 MW Gens dB(A)	**35**	**31**	**29**	**28**

Note: Acoustics treatment packages details are as follows:

- Enclosure Package 1: Sealed steel enclosure with 1 mm sheet thickness, and single stage (300 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 2: Sealed steel enclosure with 1 mm sheet thickness, and two stage (600 mm) acoustic louvers at inlet and discharge.
- Enclosure Package 3: Sealed steel enclosure with 1 mm sheet thickness, lined with 50 mm thick sound absorbing material, and 900 mm long (33%) splitter attenuators at inlet and discharge.
- Enclosure Package 4: Sealed steel enclosure with 1.6 mm sheet thickness, lined with 75 mm thick sound absorbing material, and 1500 mm long (33%) splitter attenuators at inlet and discharge.
- Cooler Package 1: Medium-grade cooler silencers.
- Cooler Package 2: High-grade cooler silencers.
- Cooler Package 3: Fan with variable fan drive (VFD) and high-grade cooler silencers.
- Cooler Package 4: Ultra low noise fan with VFD and high-grade cooler silencers.
- Muffler:Low-grade, medium-grade or high-grade mufflers.

As shown in Table 6-6, it is unlikely that the noise limit of 28 dB(A) can be achieved at less than 4 km from the CGPF while the temporary power generators are on site, even with very high performance noise control treatments applied to the dominant noise sources.

The predictions indicate that the noise criterion can be achieved at a separation distance of 4 km with medium performance noise mitigation treatments, provided no other noise from Project-related equipment is contributing at the receptor location.

The predictions indicate that the noise limit can be achieved at a distance of approximately 4 km, with moderate noise control treatments applied to the dominant noise sources.

Indicative noise level contours are provided in Appendix E, Figure-E-6 of this report for the 5-train CGPF powered by 5.7 MW gas turbine generators with noise mitigation implemented with the aim of achieving the noise limit at 4 km from the plant. With the selected noise treatments, the 28 dB(A) noise contour is predicted at approximately 4 km from the CGPF plant.

6.5 Flaring Noise

Predicted noise levels from flaring at FCFs are expected to be relatively minor at distances of more than 2 km.

Predicted noise levels from flaring at CGPFs are expected to be more substantial and may exceed the medium-term noise criterion of 28 dB(A) at distances up to about 8 km from the CGPFs during the highest flaring rates combined with worst case weather conditions. Flaring events with the highest flaring rates are not expected to occur more frequently than once every two years, for a maximum period up to 21 hours.

Options for mitigation of flare noise using engineering noise control treatments are limited, and the industry standard for modern flare stack tips typically includes best available noise control technology in the stack tip design.

Opportunities to include further improve the noise reduction treatments in the CGPF flare stack tip designs will be investigated during the detailed design phase. Strategies for management of noise impact from flaring will be incorporated into the Project Environmental Management Plan (currently presented in the EIS as the Draft Environmental Management Plan (Appendix Z)).

7 CONCLUSIONS

This supplementary assessment has investigated the changes to the potential environmental noise and vibration impacts associated with the Project as a result of the updated project description.

The assessment has demonstrated that the Project noise limit criteria can be achieved for individual facilities using a combination of noise attenuation by distance and engineering noise control treatments to plant and equipment. In some cases significant noise control treatments may be required. In all cases the amount of noise reduction required will depend on the proximity of sensitive receptors.

As the locations of the plant are not yet known, the proximity to sensitive receptors cannot be gauged; however the noise level predictions in this report can provide guidance to inform the Project in helping to select suitable plant locations based on the distance to receptors. This will allow the Project to follow the noise management hierarchy in the *Prescribing noise conditions for environmental authorities for petroleum activities* guideline:

1. Avoid the noise impact;
2. Minimise the noise impact, in the order of:
    a. Orientate an activity to minimise noise; and
    b. Use the best available technology;
3. Manage the noise impact.

Additionally, the noise level predictions in this report and in the EIS will also be used to inform the Project in the selection of suitable site locations for plant and facilities by taking into consideration the contribution of individual plant toward cumulative noise impacts.

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9 LIMITATIONS

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APPENDIX A SOUND POWER LEVELS - CONSTRUCTION EQUIPMENT

Table-A-1 Typical Construction Equipment Sound Power Levels

Noise Source	Estimated Overall Sound Power Level dB(A)
Construction equipment	
Truck (50 Tonne, 35 km/hr) (from BS5228 Table D.9)	120
Front end loader (37 kW) (from BS5228 Table D.3)	118
Excavator (approx. 75 kW)	118
Dozer (201 kW) (from BS5228 Table D.3)	120
Grader (205 kW)	118
Scraper (109 kW)	116
Rock saw	118
Crane	115
Bobcat	105
Drill rig	115
Generator	119
Welding generator	113
Air compressor	107
Hand-held grinder	106
Completion drill rig	116
Concrete Batching Plant	110
Process	
Hydraulic fracturing	110

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APPENDIX B SOUND POWER LEVELS - OPERATIONAL NOISE SOURCES

Table-B-1 Sound Power Levels - Operational Noise Sources

Noise Source	Number of items	Sound Power Level (dB)								Overall
		63	125	250	500	1,000	2,000	4,000	8,000	dB(A)
Wells										
22 kW electric motor	1 per production well	82	83	82	79	79	74	72	63	83
5.7 L V8 60 kW gas engine	4 well pad: 1 8 & 12 well pad: 2 (at maximum 10% of well pads)	63	73	82	74	79	73	70	77	86
FCFs										
LP Screw Compressor 20 TJ/d	1 per train	98	103	104	102	106	122	110	101	124
HP Screw Compressor 20 TJ/d	1 per train	99	104	105	103	107	123	111	102	125
2.6 MW electric motor	2 per train	96	98	98	98	98	98	95	88	104
Coolers	1 per train	113	112	109	104	101	94	90	84	107
Water transfer pump & motor 150 kW	4 per FCF	101	104	102	97	95	88	82	76	100
Flares at FCFs										
120 TJ/d	1 per FCF	105	110	105	95	90	95	105	100	108
210 TJ/d	1 per FCF	108	113	108	98	93	98	108	103	111
CGPF										
Centrifugal compressor	1 per train	102	102	97	101	107	104	113	113	117

Noise Source	Number of items	Sound Power Level (dB)								Overall
		63	125	250	500	1,000	2,000	4,000	8,000	dB(A)
9 MW electric motor	1 per train	92	93	95	104	100	98	96	92	106
Cooler	1 per train	111	110	107	102	99	92	88	82	108
<u>Flares at CGPFs</u>										
80 kg/sec	1 per CGPF	119	125	128	130	132	134	133		139
31 kg/sec	1 per CGPF	114	120	123	125	127	129	128		134
14 kg/sec	1 per CGPF	111	117	120	122	124	126	125		131
7 kg/sec	1 per CGPF	108	114	117	119	121	123	122		128
<u>WTFs (Co-located at CGPFs)</u>										
Centrifugal Pump 55 kW	25 per WTF	92	93	95	95	98	95	91	85	101
Centrifugal Pump 110 kW	10 per WTF	95	96	98	98	101	98	94	88	105
Centrifugal Pump 310 kW	8 per WTF	98	99	101	101	104	101	97	91	107
Electric Motor 55 kW	25 per WTF	96	99	101	104	104	103	98	90	108
Electric Motor 110 kW	10 per WTF	99	102	104	107	107	106	101	93	111
Electric Motor 315 kW	8 per WTF	93	95	95	95	95	95	92	85	101
Pressure Control Valve	24 per WTF	64	74	82	88	92	85	74	61	94
<u>Temporary Power Supply at FCFs and CGPFs Option 1 at FCFs: 1.1 MW gas engine generators</u>										
Mechanical Noise	1 per gen	90	91	93	91	92	92	97	88	101
Exhaust	1 per gen	110	112	104	97	94	88	83	83	101
Cooler	1 per gen	111	110	107	102	99	92	88	82	105

Noise Source	Number of items	Sound Power Level (dB)								Overall
		63	125	250	500	1,000	2,000	4,000	8,000	dB(A)
Temporary Power Supply at FCFs and CGPFs Option 2 at FCFs 5.7 MW Gas Turbine										
Air Inlet	1 per gen	106	109	113	113	100	87	73	102	108
Mechanical	1 per gen	107	101	102	103	104	100	100	96	106
Exhaust	1 per gen	118	120	113	111	109	98	93	90	109
Lube Oil Cooler	1 per gen	104	111	108	102	96	94	90	86	100
Cooler	4 per gen	109	111	110	107	102	99	92	88	104

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APPENDIX C PREDICTED NOISE LEVEL CONTOURS WITHOUT ADDITIONAL NOISE MITIGATION

Figure-C-1 Indicative noise level contours: Pair of 4-well pads - electrically powered (without noise mitigation)

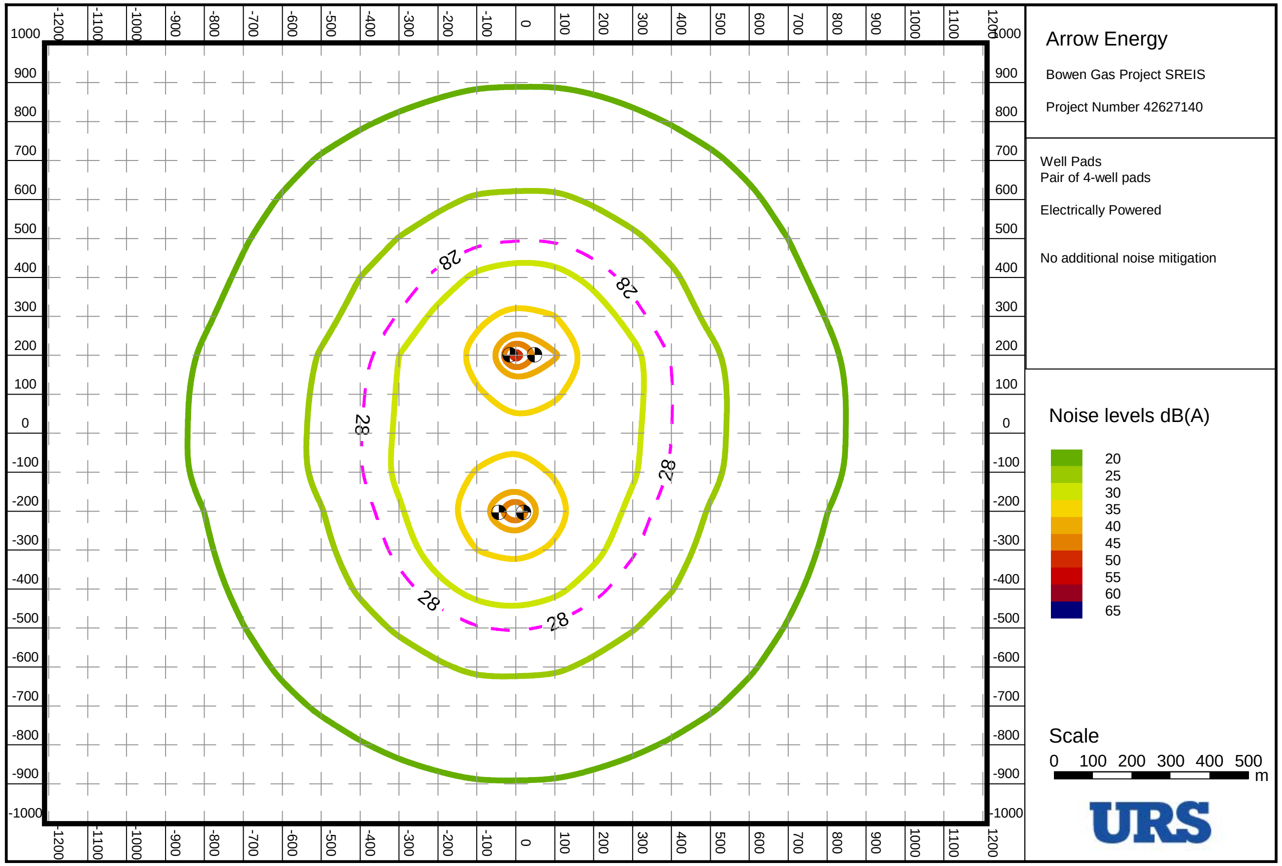


Figure-C-2 Indicative noise level contours: Pair of 4-well pads - local power generators (without noise mitigation)

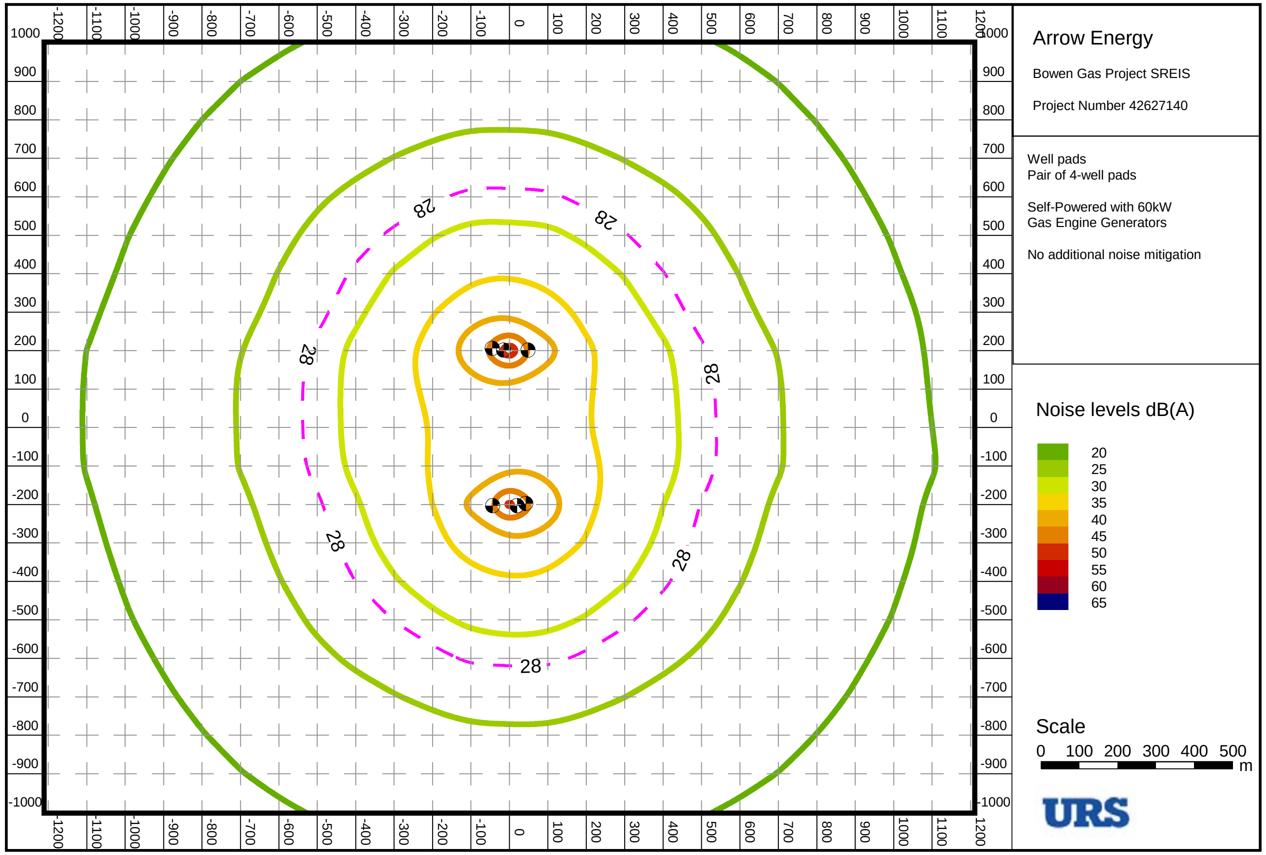


Figure-C-3 Indicative noise level contours: Pair of 8-well pads - electrically powered (without noise mitigation)

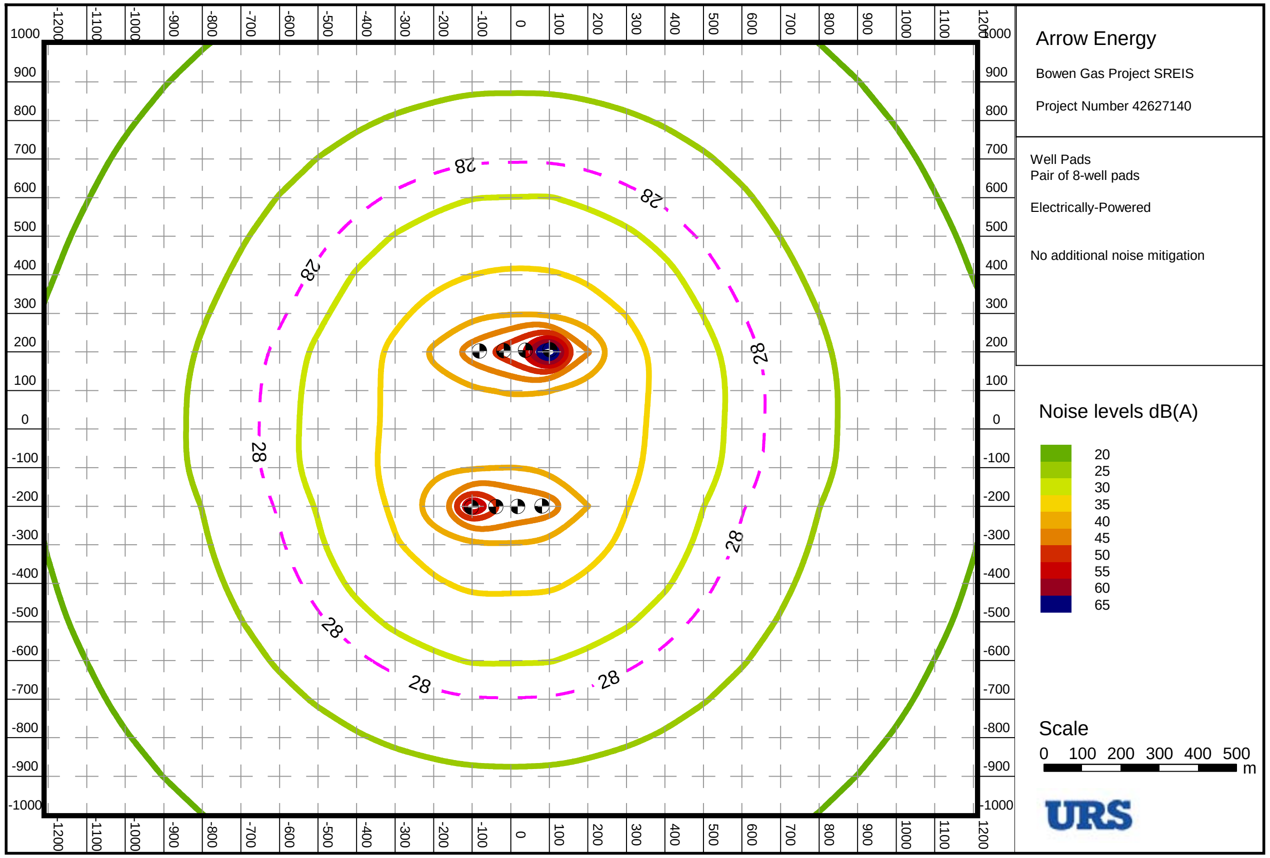


Figure-C-4 Indicative noise level contours: Pair of 8-well pads - local power generators (without noise mitigation)

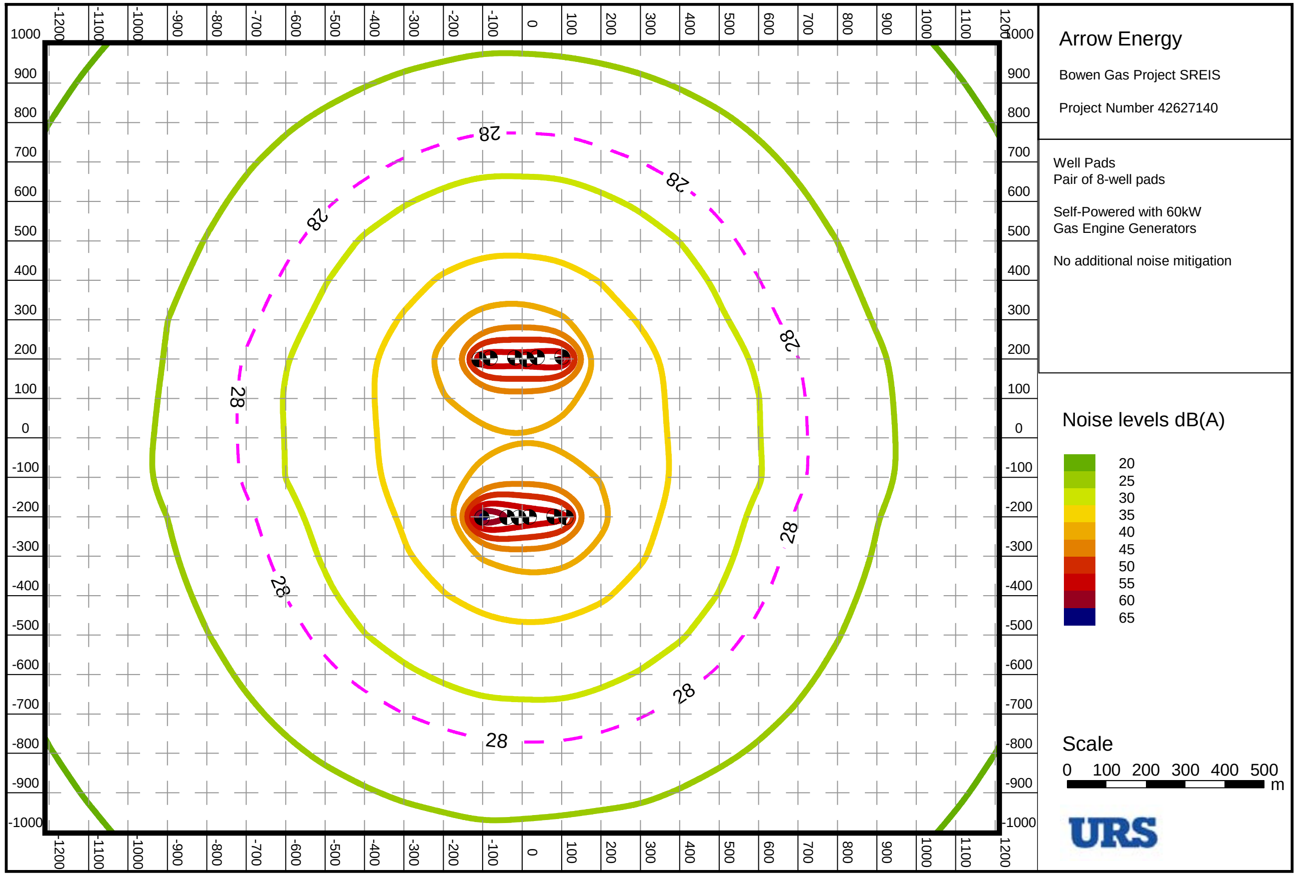


Figure-C-5 Indicative noise level contours: Pair of 12-well pads - electrically powered (without noise mitigation)

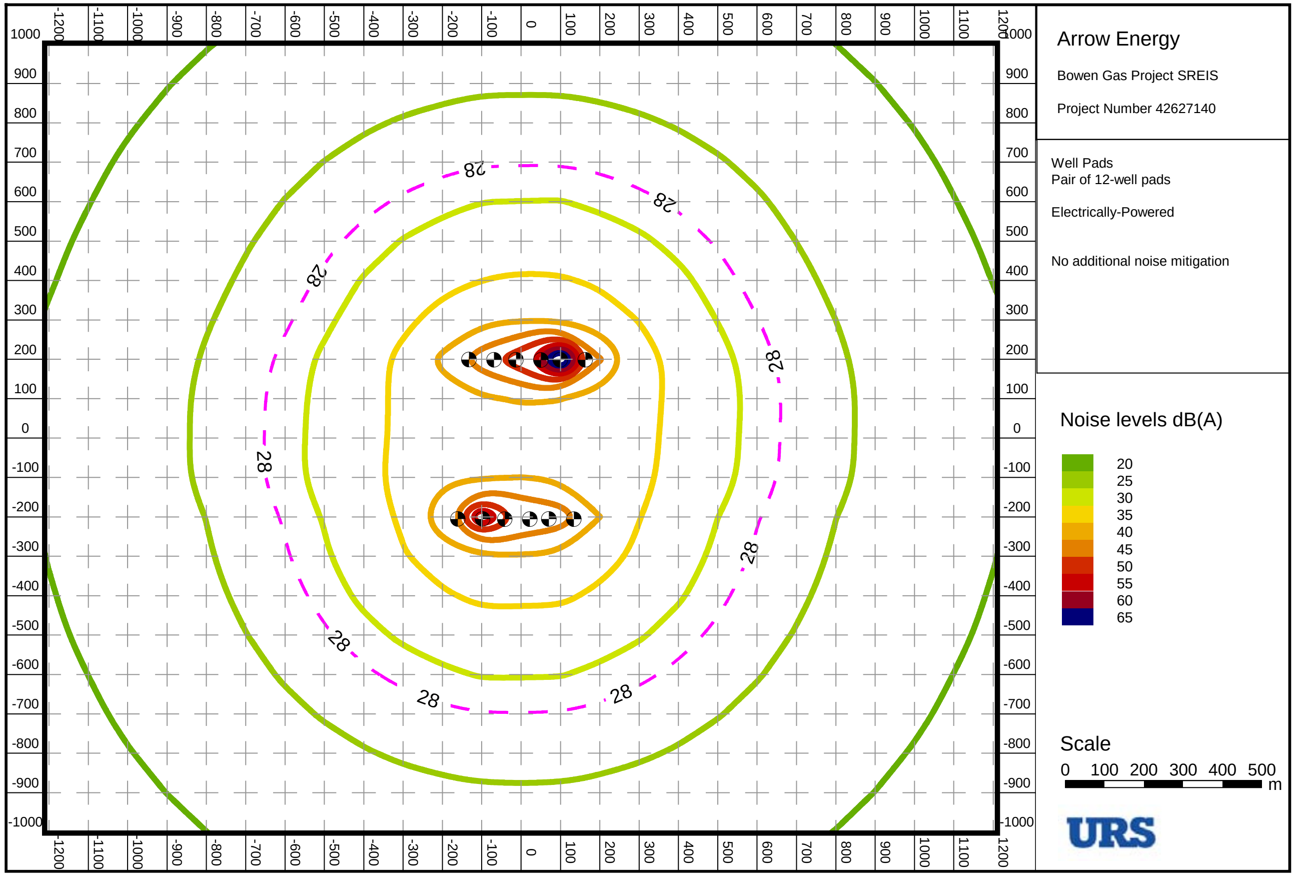


Figure-C-6 Indicative noise level contours: Pair of 12-well pads - local power generation (without noise mitigation)

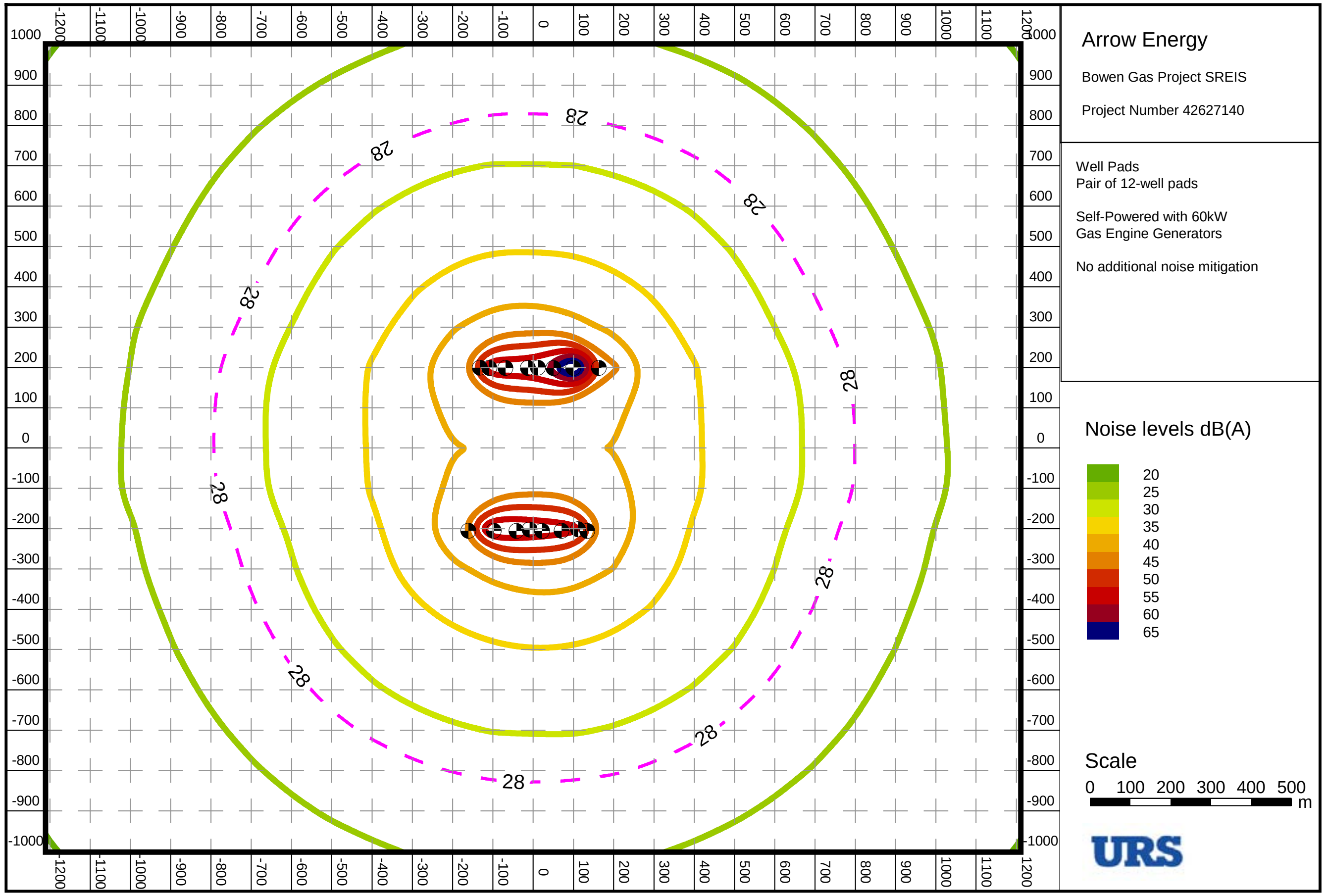


Figure-C-7 Indicative noise level contours: FCF (3-train) – electrically powered (without additional noise mitigation)

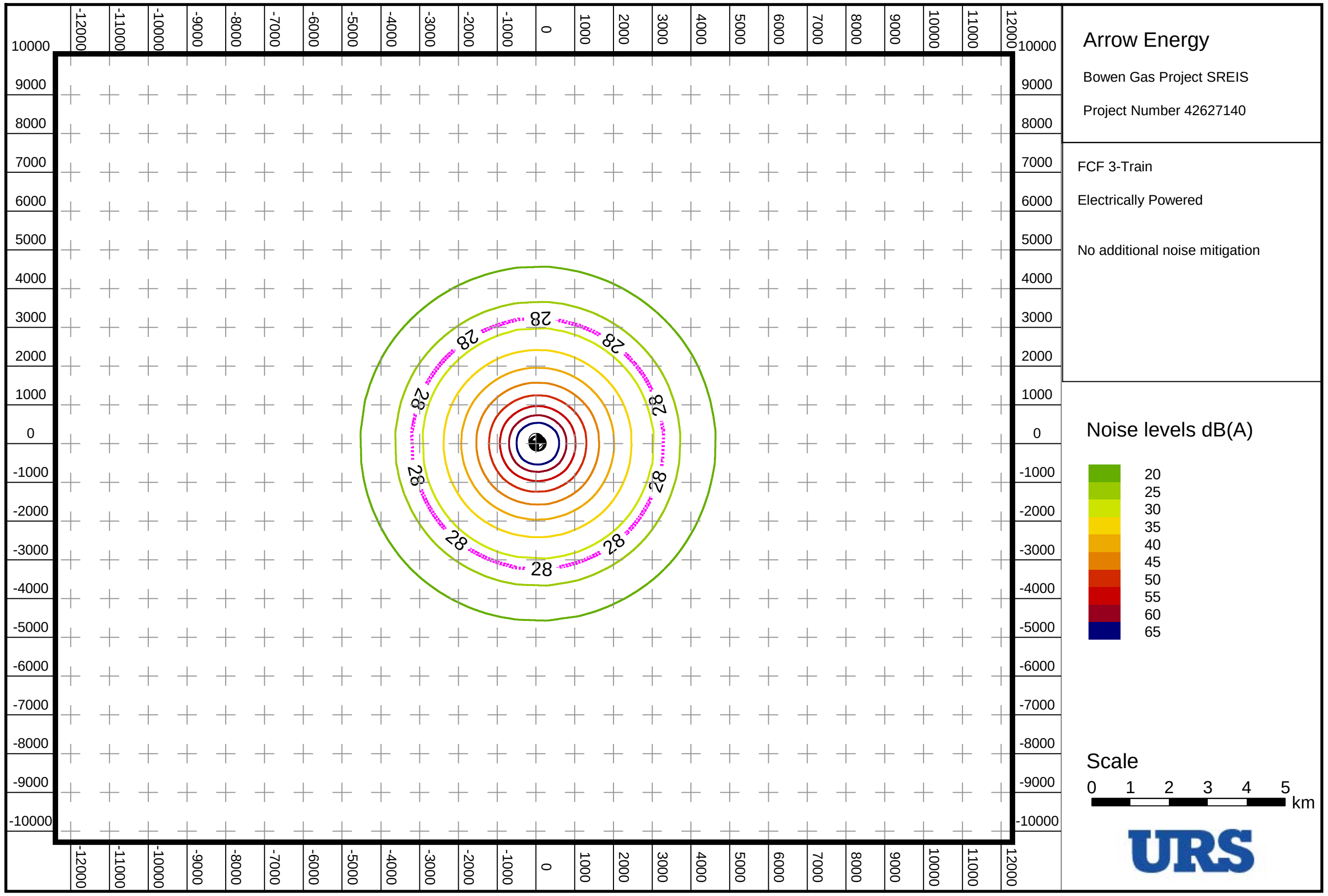


Figure-C-8 Indicative noise level contours: FCF (3-train) – 1.1 MW local power generators (without additional noise mitigation)

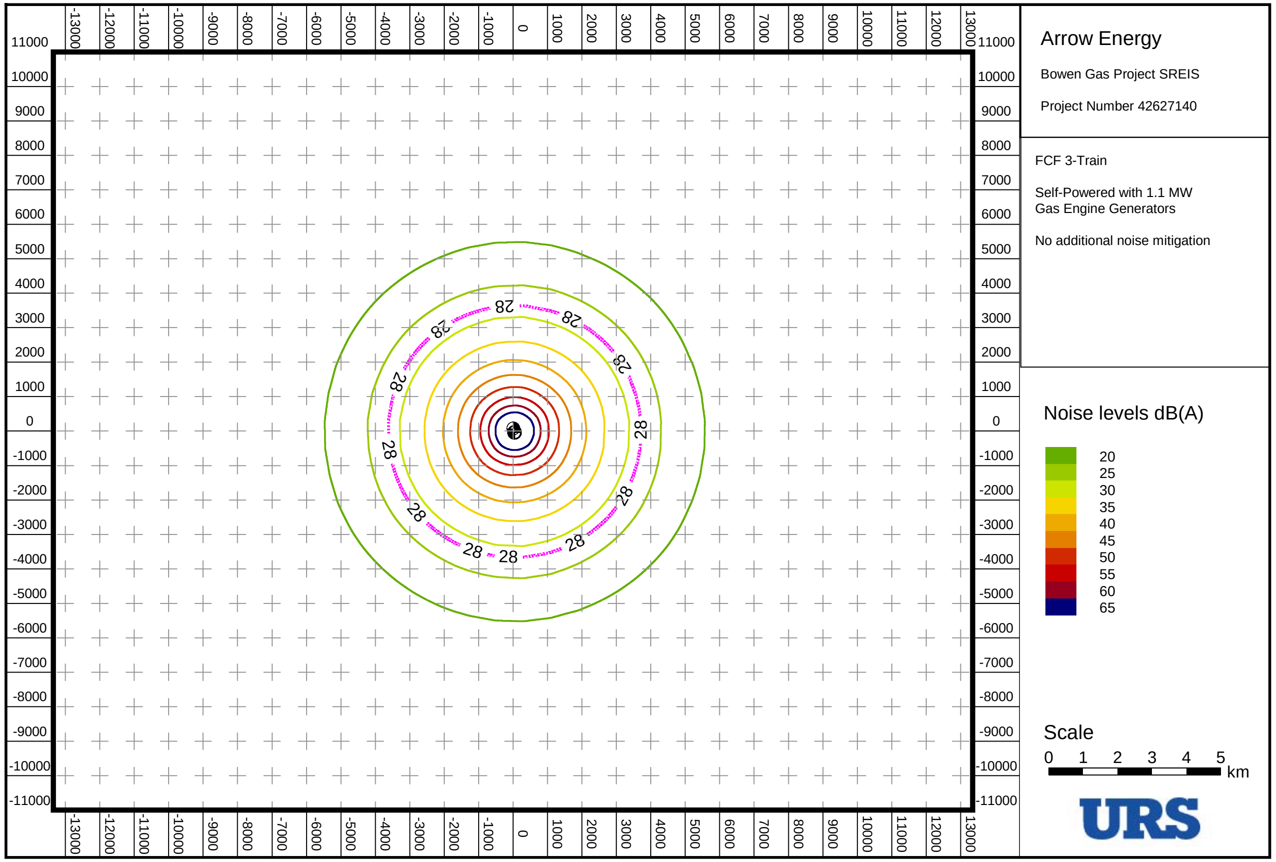


Figure-C-9 Indicative noise level contours: FCF (3-train) – 5.7 MW local power generators (Without additional noise mitigation)

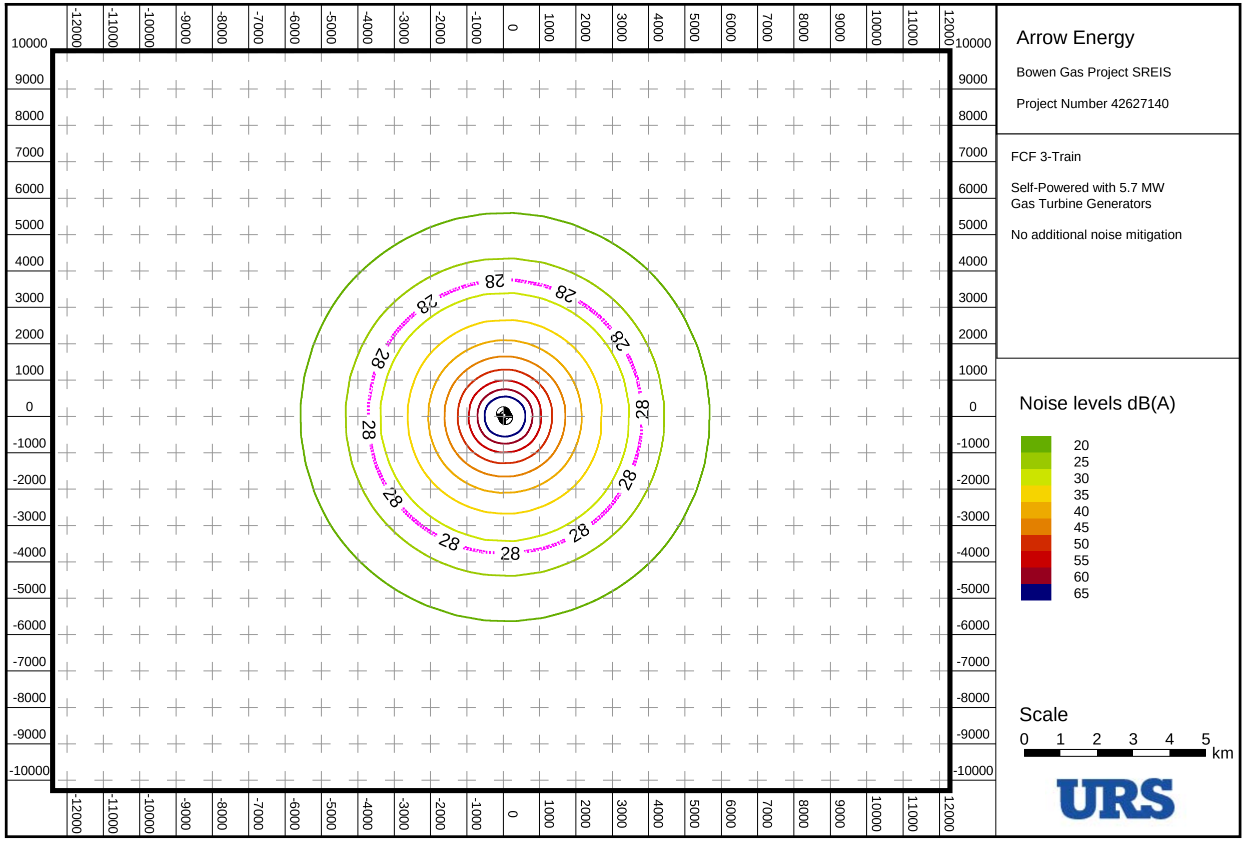


Figure-C-10 Indicative noise level contours: FCF (7-train) – electrically powered (without additional noise mitigation)

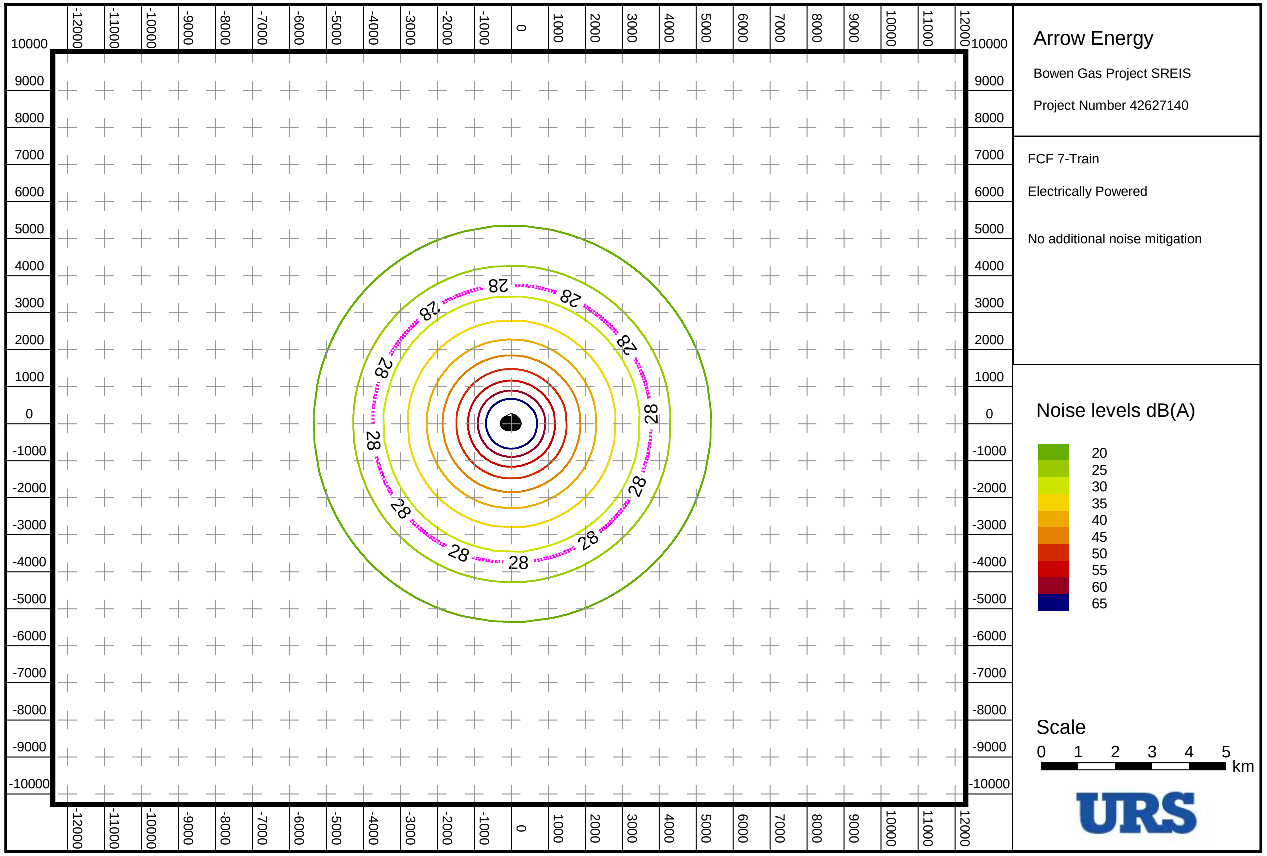


Figure-C-11 Indicative noise level contours: FCF (7-train) – 1.1 MW local power generators (without additional noise mitigation)

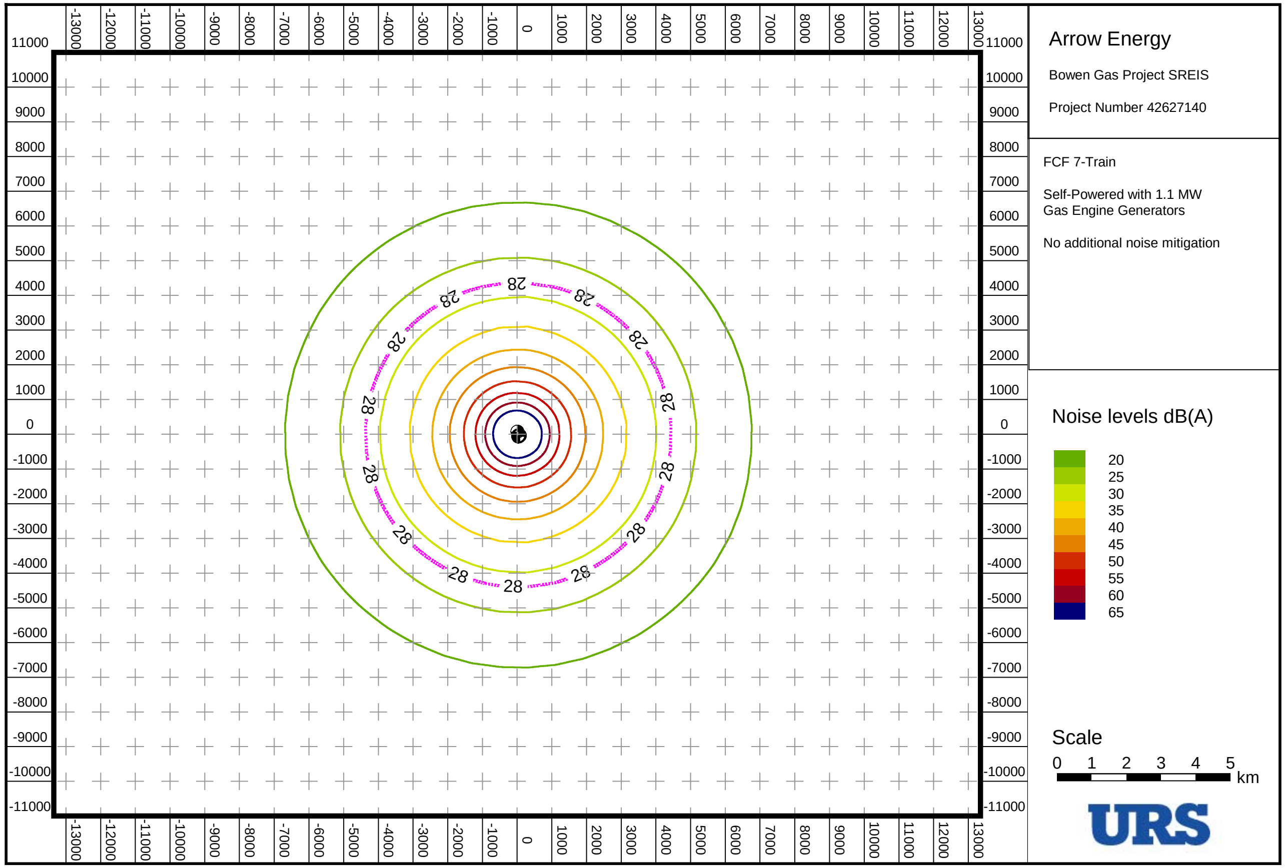


Figure-C-12 Indicative noise level contours: FCF (7-train) – 5.7 MW local power generators (Without additional noise mitigation)

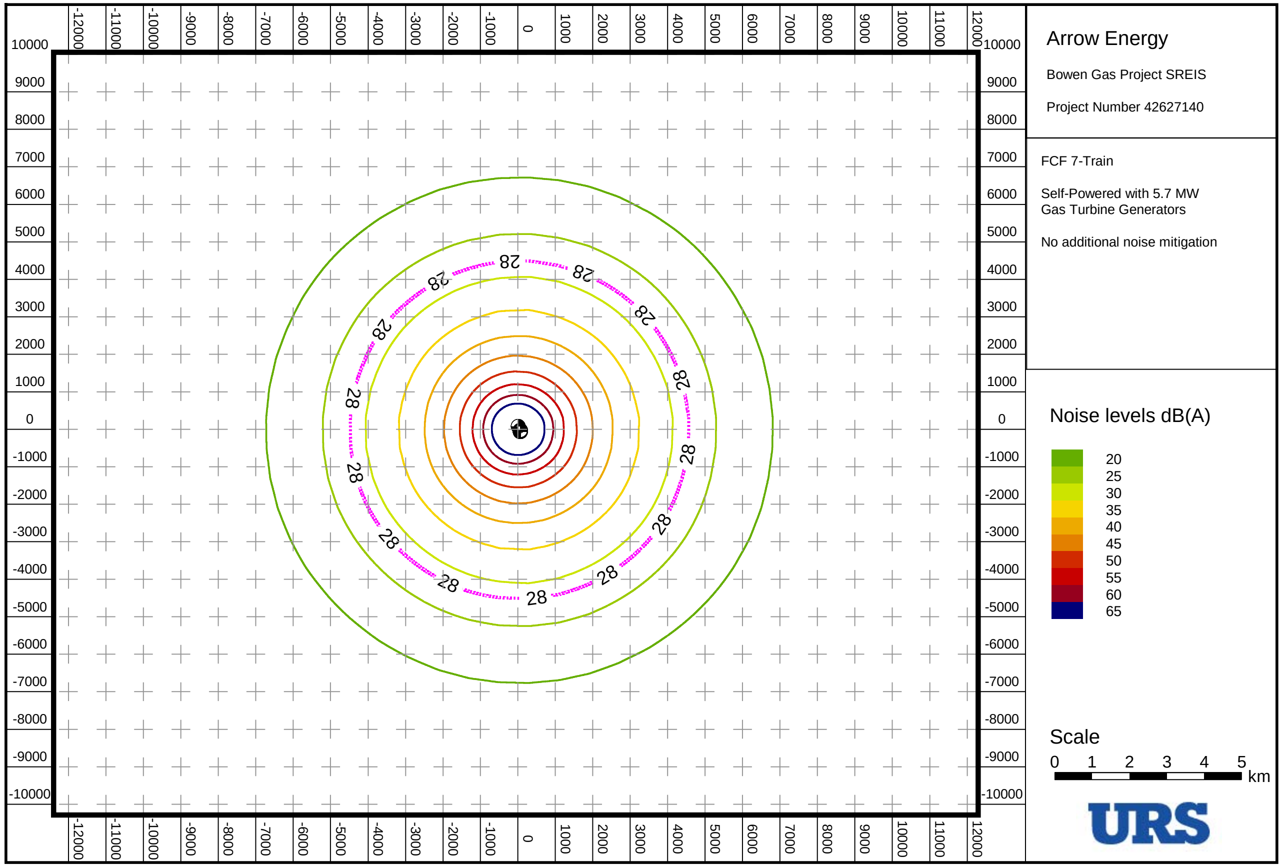


Figure-C-13 Indicative noise level contours: CGPF (5-train) – electrically powered (without additional noise mitigation)

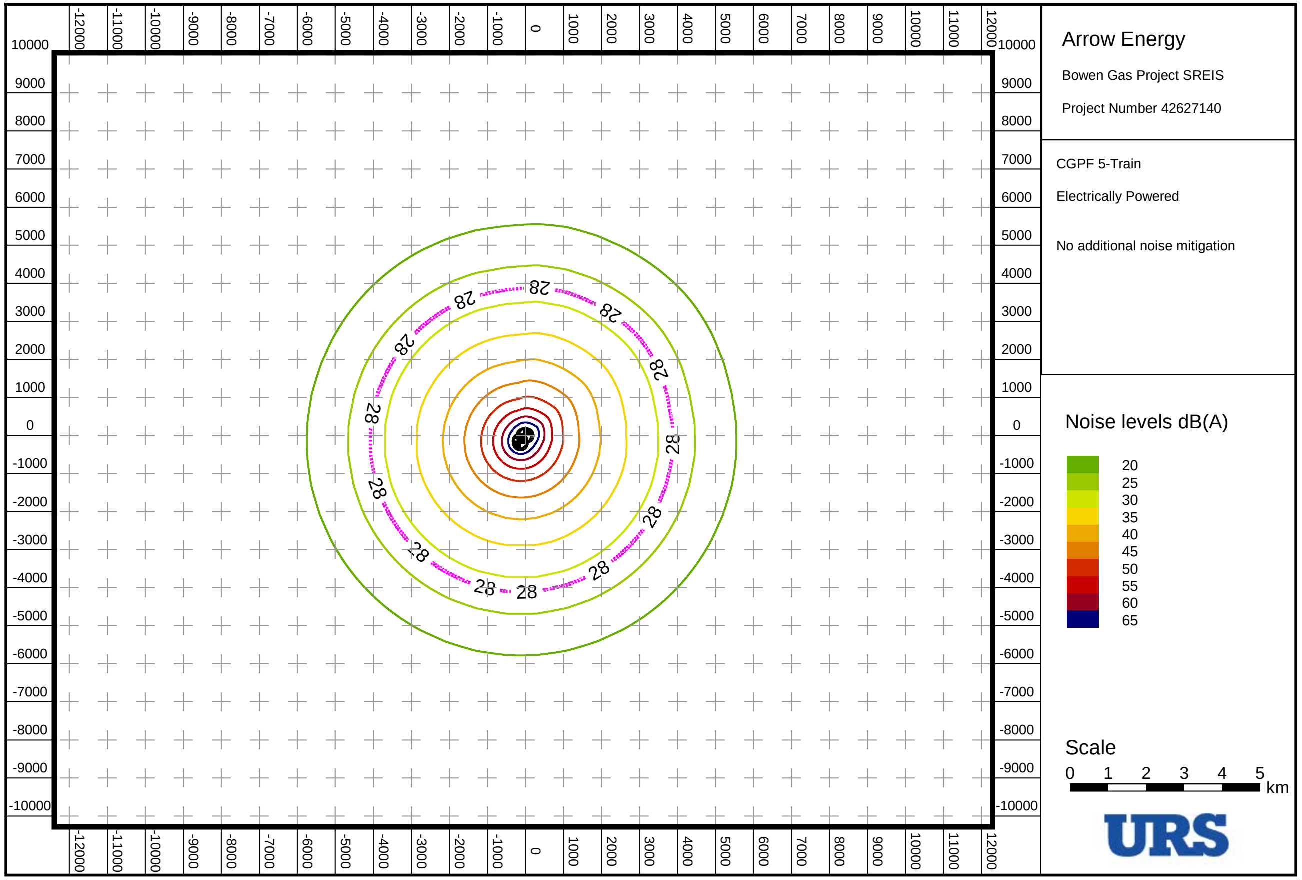


Figure-C-14 Indicative noise level contours: CGPF (5-train) – 1.1 MW local power generators (without additional noise mitigation)

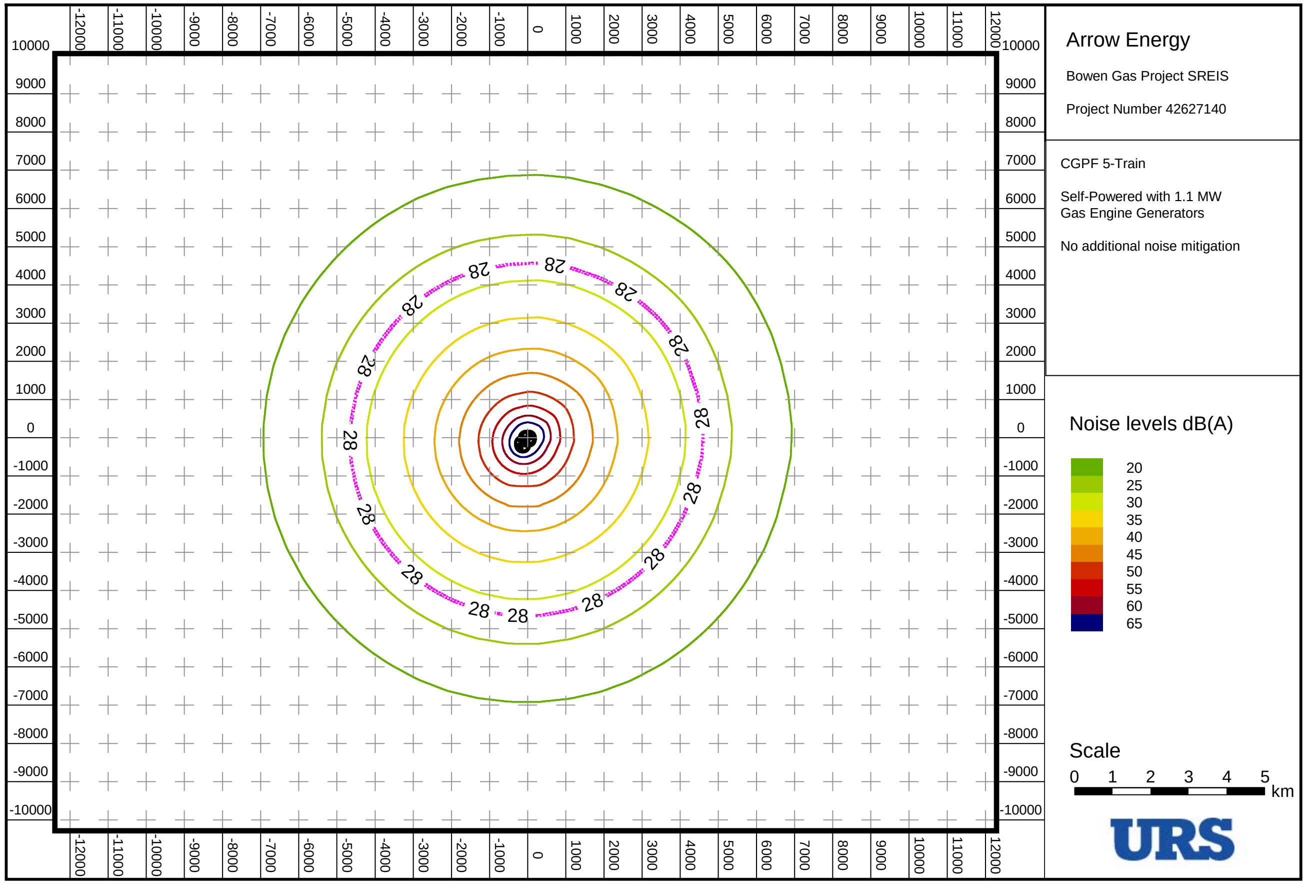
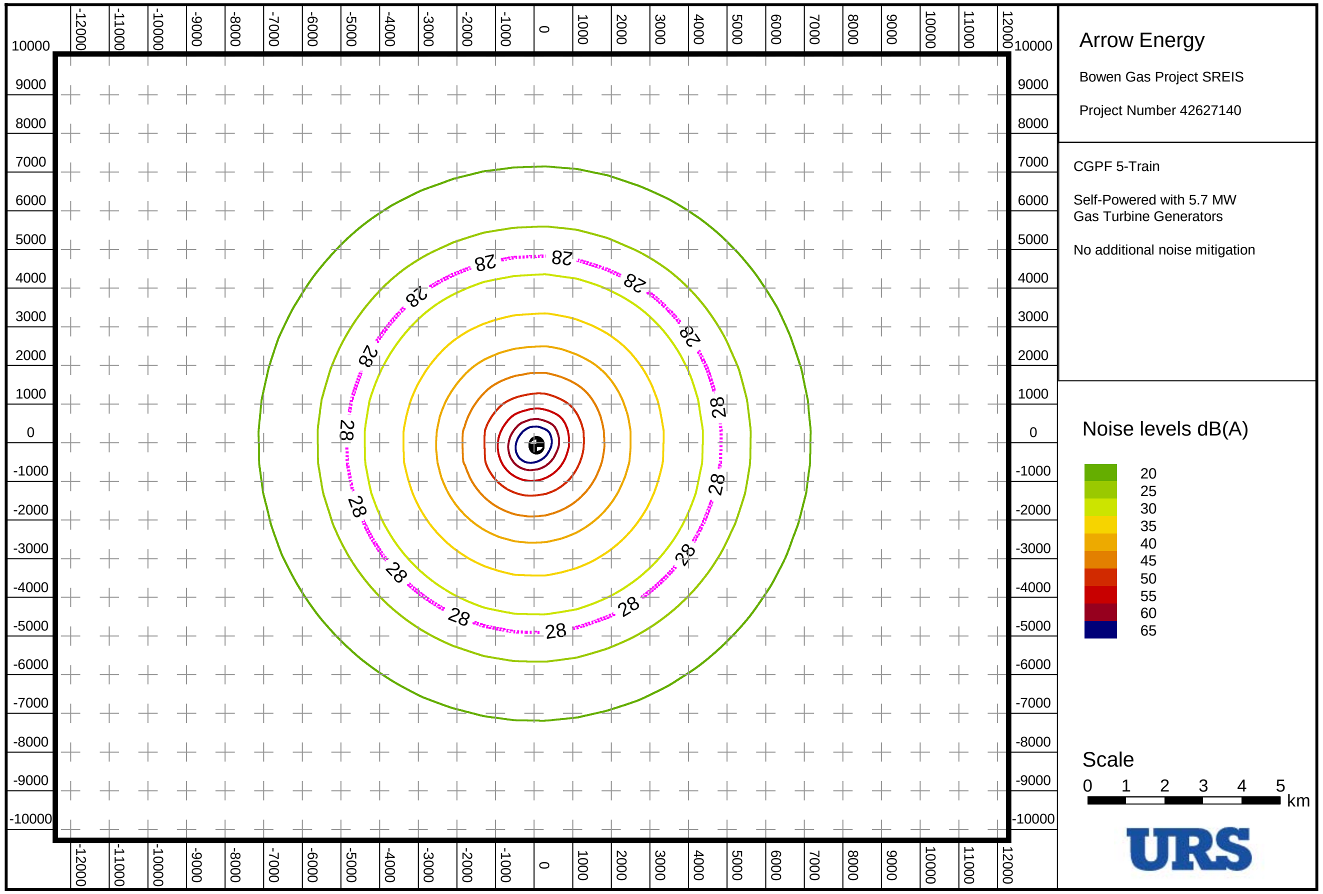


Figure-C-15 Indicative noise level contours: CGPF (5-train) – 5.7 MW local power generators (without additional noise mitigation)



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APPENDIX D ACOUSTICS ATTENUATION PACKAGES

Table-D-1 Acoustics Attenuation Treatment Packages

Acoustics Treatment Package	Insertion loss – [dB] Frequency (Hz)						
	63	125	250	500	1000	2000	4000
E1: Sealed steel enclosure with 1 mm sheet thickness, and single stage acoustic louvers at inlet and discharge.	0	8	8	11	21	24	16
E2: Sealed steel enclosure with 1 mm sheet thickness and two stage (600 mm) acoustic louvers at inlet and discharge.	0	10	19	21	26	34	17
E3: Sealed steel enclosure with 1 mm sheet thickness, lined with 50 mm thick sound absorbing material and 900 mm long (33%) splitter attenuators at inlet and discharge.	5	10	21	39	46	41	18
E4: Sealed steel enclosure with 1.6 mm sheet thickness, lined with 75 mm thick sound absorbing material and 1500 mm long (33%) splitter attenuators at inlet and discharge.	15	18	22	28	30	25	10
C1: Medium-grade cooler silencers.	0	1	3	8	6	3	0
C2: High-grade cooler silencers.	2	8	10	16	14	10	0
C3: Fan with variable fan drive (VFD) and high-grade cooler silencers.	9	13	15	18	20	11	0
C4: Ultra low noise fan with VFD and high-grade cooler silencers.	15	18	22	28	30	25	10
Muffler (Low-grade)	0	0	0	2	5	2	0
Muffler (Medium-grade)	0	2	3	5	8	2	0
Muffler (High-grade)	0	5	10	15	20	15	10

APPENDIX E NOISE CONTOUR MAPS - WITH MITIGATION

Figure-E-1 FCF 7-train Electrically powered, with mitigation to achieve noise limit at 1 km

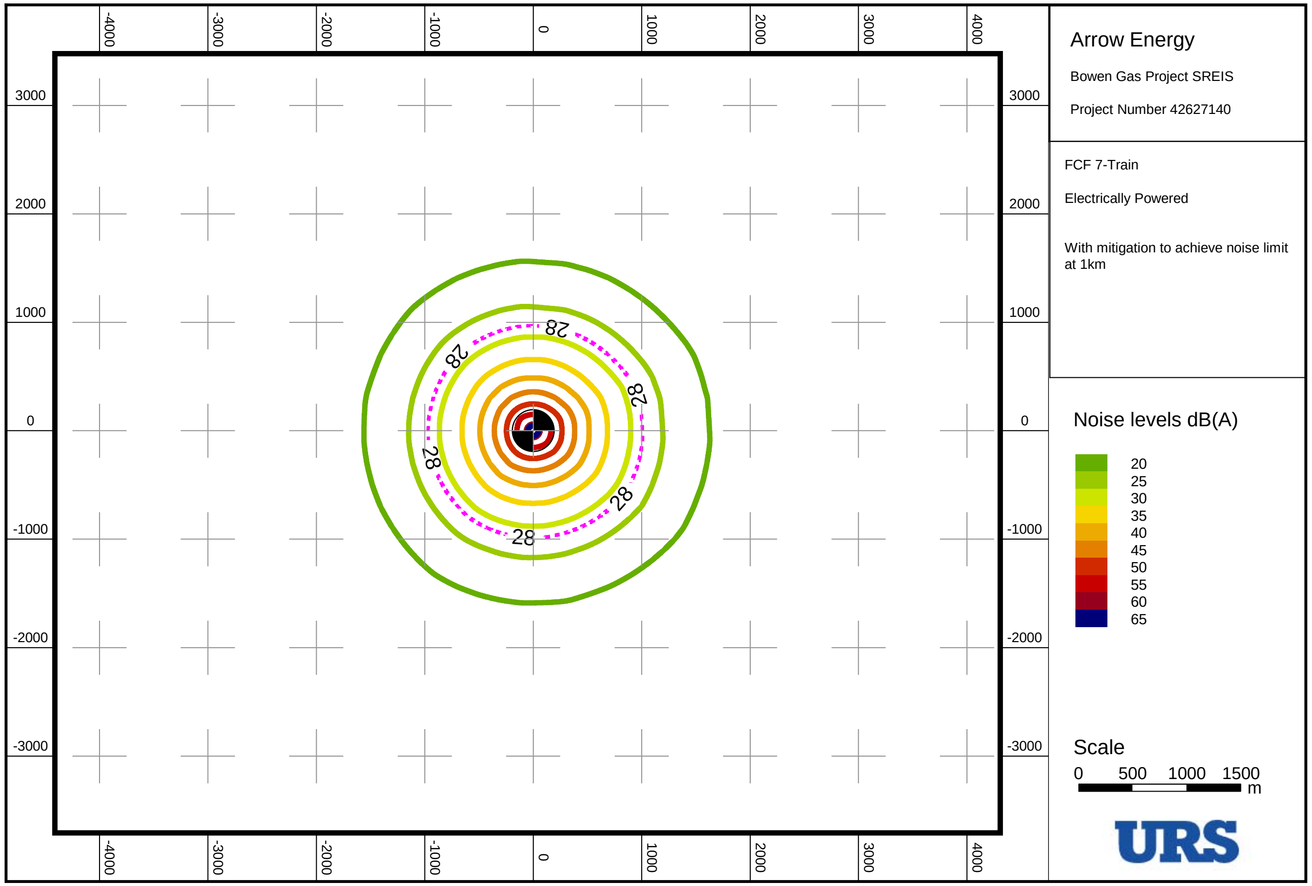


Figure-E-2 FCF 7-train with temporary local power generation by 1.1 MW gas engines, with mitigation to achieve noise limit at 3 km

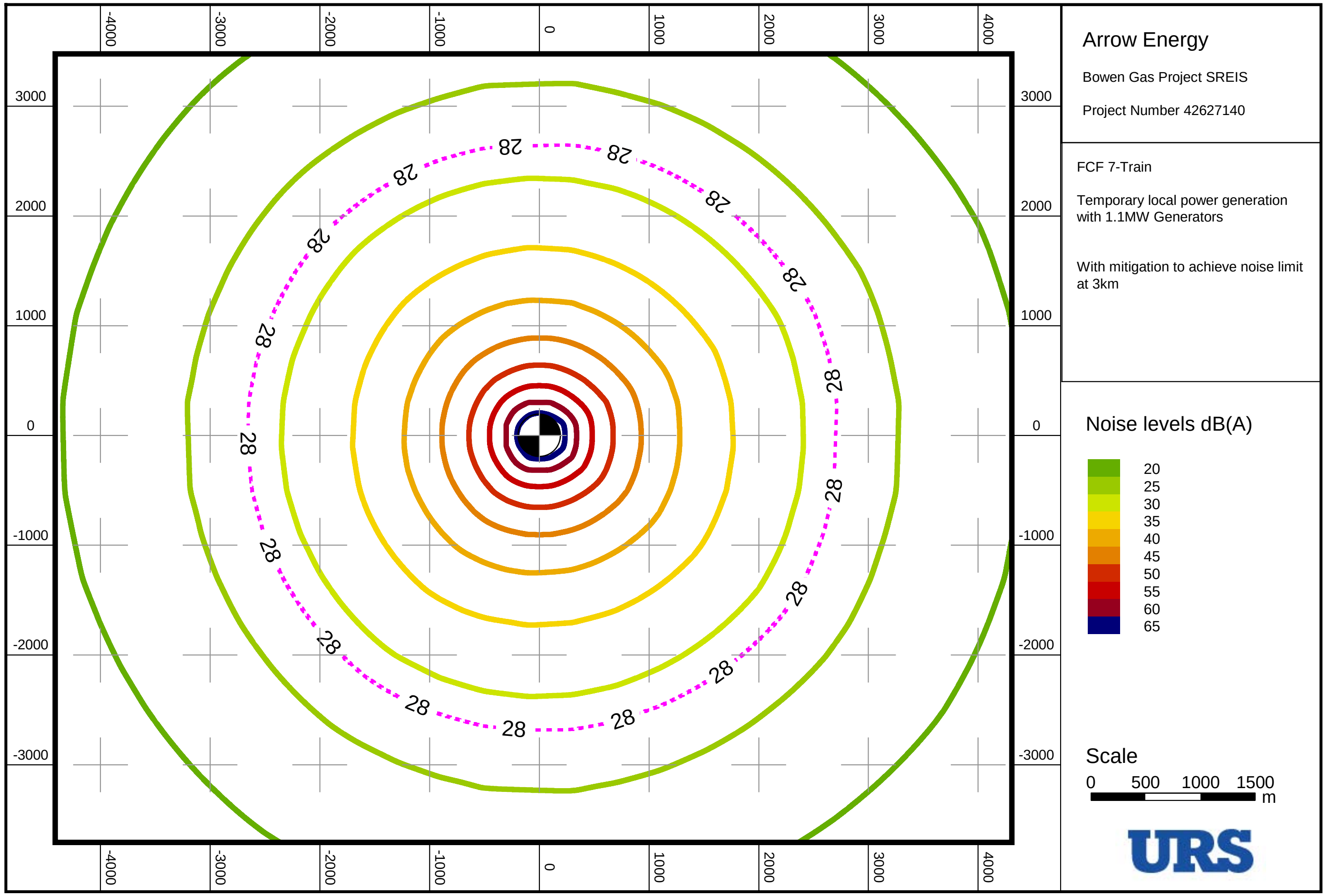


Figure-E-3 FCF 7-train with temporary local power generation by 5.7 MW gas turbines, with mitigation to achieve noise limit at 3 km

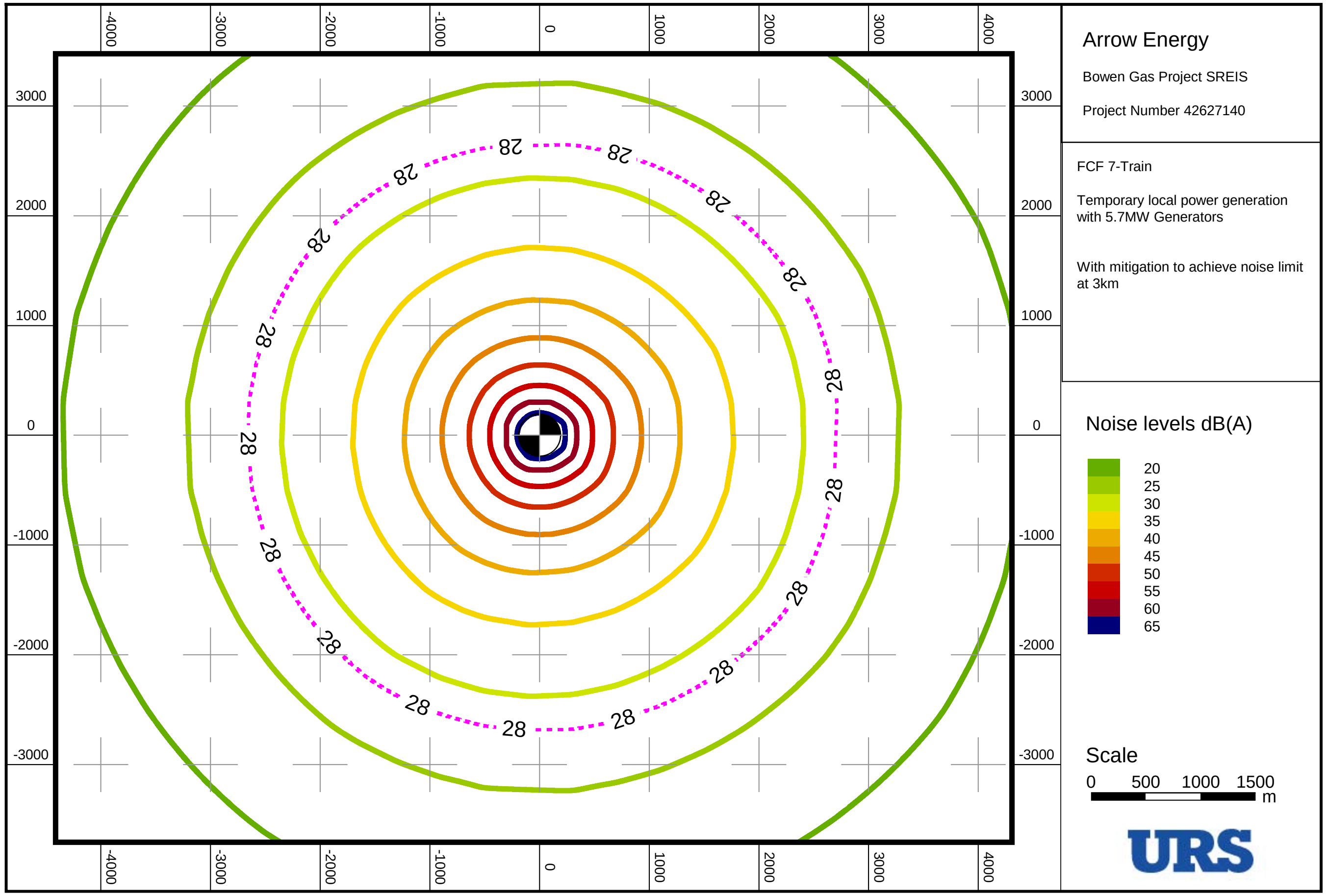


Figure-E-4 CGPF 5-train and WTF - Electrically Powered - With Mitigation to achieve limit at 1 km

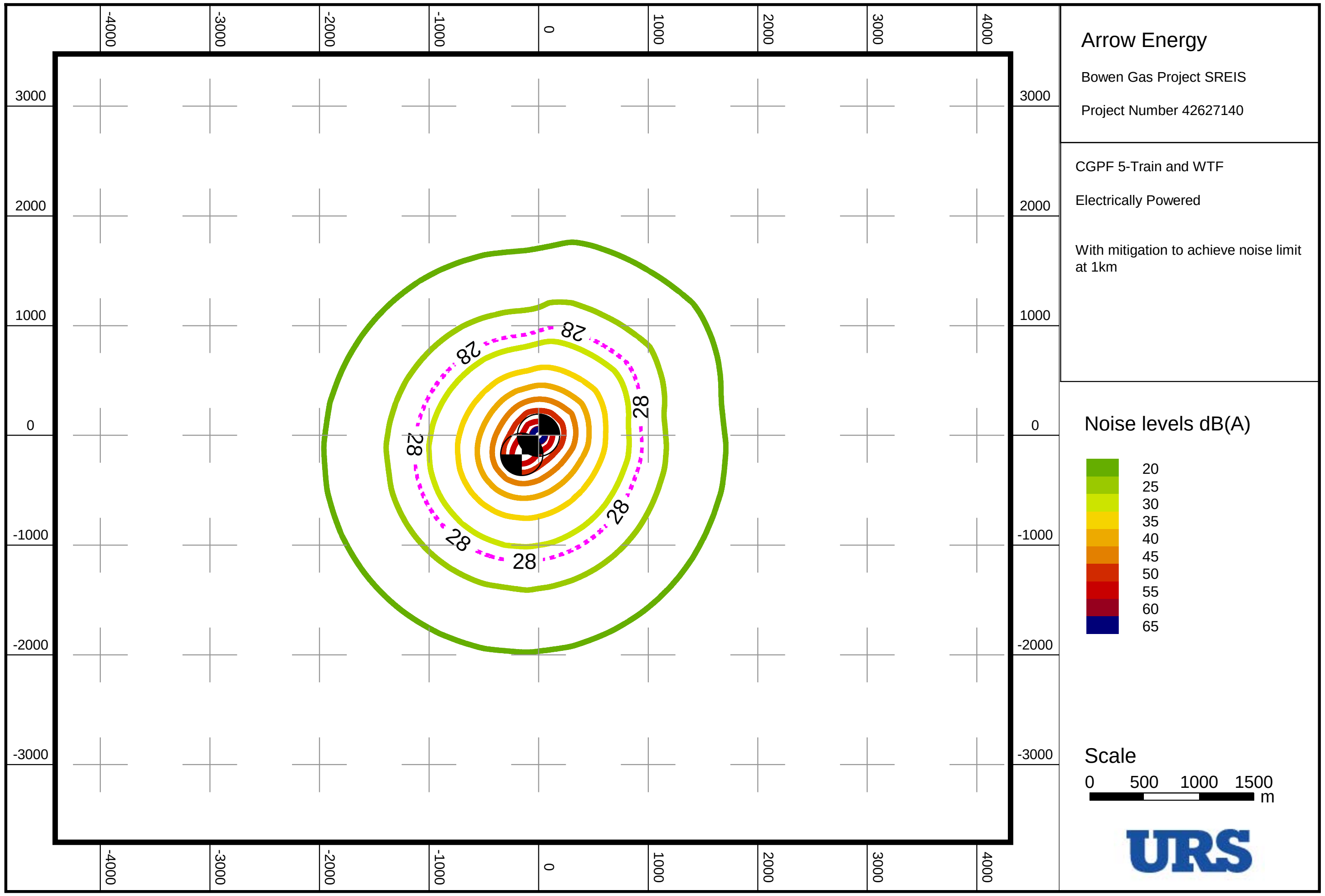


Figure-E-5 CGPF 5-train and WTF - temporary power by 1.1 MW generators - with mitigation to achieve limit at 3 km

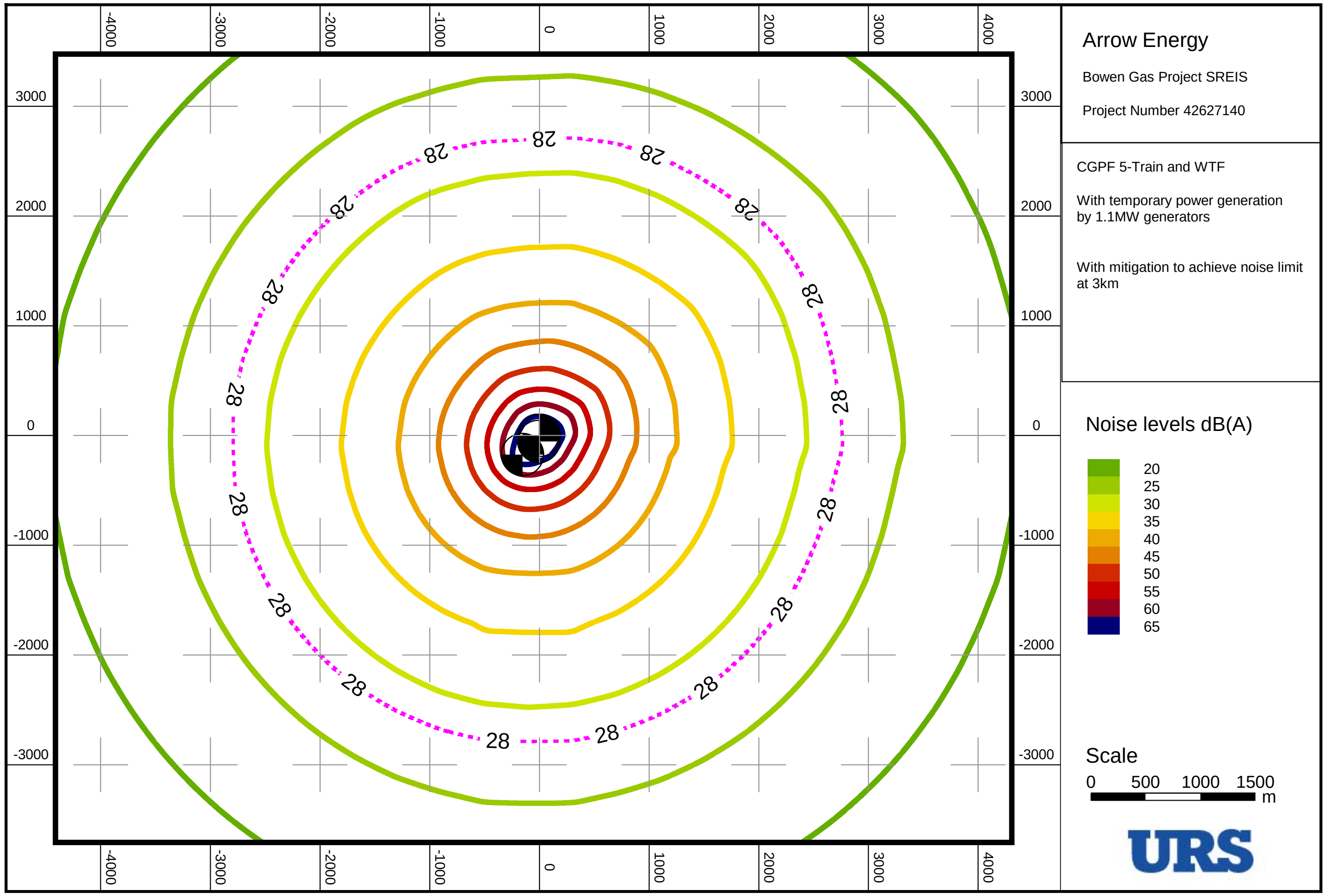
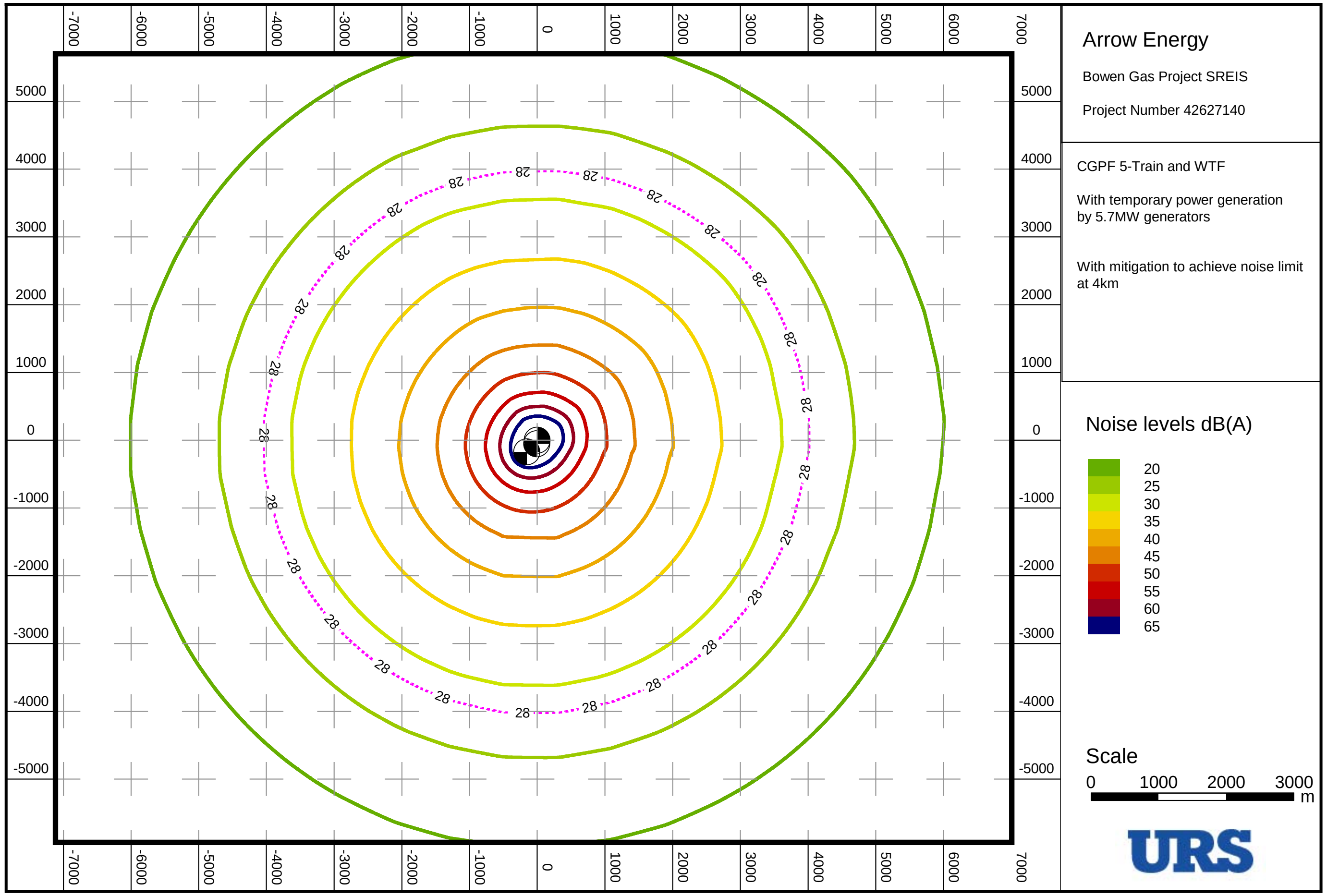


Figure-E-6 CGPF 5-train and WTF - temporary power by 5.7 MW Generators - with mitigation to achieve limit at 4 km



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