APPENDIX 4

ARROW LNG PLANT

Supplementary Noise and Vibration Impact Assessment

arrow energy
go further

Sonus Pty Ltd
17 Ruthven Avenue
ADELAIDE SA 5000
Phone: (08) 8231 2100
Facsimile: (08) 8231 2122
www.sonus.com.au
ABN: 67 882 843 130

Arrow LNG Plant

Supplementary Noise and Vibration Impact Assessment

Prepared For

Coffey Environments Australia Pty Ltd

on behalf of

Arrow CSG (Australia) Pty Ltd

S3328C13
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EXECUTIVE SUMMARY

A supplementary assessment has been made of the environmental noise and vibration impact from the operation and construction of the Arrow LNG Plant (the project) to account for the changes to the project description.

The general changes to the project description which are relevant to the noise and vibration impact assessment include revised power options and gas turbine generators; updated plant equipment, sound power levels and location; additional construction equipment information; and additional dredging at two dredge sites.

The assessment has maintained the method and criteria developed in the initial noise and vibration impact assessment. The assessment specifically determines the noise and vibration impact for project components which are related to the changes to the project description. For other project components, the impact assessment and conclusion are as per the initial assessment.

Based on predictions, the operational noise conditions will be achieved at the noise sensitive receptors with a feasible level of acoustic treatment applied to equipment at the LNG plant.

The construction equipment information is consistent with the assumptions considered in the initial assessment, therefore the noise impact and mitigation requirements provided in the S3328C6 Report for construction noise remain valid.

Prediction of the noise from dredging activity at the two dredge sites with additional areas of dredging indicates that the noise level at noise sensitive receptors will achieve the established criteria.

The vibration impact from the project as determined in the initial assessment remains valid considering that the main factors which control vibration impact, such as the type of vibration source (i.e., type of equipment) and distance from the sensitive receptors, have not varied significantly with the changes to the project description.

As the noise and vibration impact of the project does not change with the changes to the project description, the conclusions for the cumulative impact assessment in the S3328C6 Report remain valid.

GLOSSARY

A weighting	Frequency adjustment representing the response of the human ear.
AL	Assessment Location which is representative of other sensitive receptors in the vicinity of the project.
CONCAWE	The oil companies' international study group for conservation of clean air and water in Europe. "The propagation of noise from petrochemical complexes to neighbouring communities".
CONCAWE noise propagation model	The CONCAWE noise propagation model is a model which takes into account topography, ground absorption, air absorption and meteorological conditions. It is used around the world and is widely accepted as an appropriate model for predicting noise over significant distances. The CONCAWE noise propagation model can be implemented in a noise modelling software such as SoundPlan.
DEHP	Department of Environment and Heritage Protection.
DERM	Department of Environment and Resource Management.
dB(A)	A weighted noise or sound power level in decibels.
EPP(Noise)	Environmental Protection (Noise) Policy 2008.
EIS	Environment Impact Statement.
FEED	Front End Engineering and Design.
$L_{pA,LF}$	Indoor low frequency A weighted noise level.
LNG	Liquefied Natural Gas.
MOF	Material Offloading Facility.
Partial Auxiliary Power Import	Part of the LNG site power requirement can be imported via dual circuit from the public power grid and part of the power requirement will be generated at the LNG plant site by means of Gas Turbine Generators.
Power Island Mode	Base case in which all power required for the operation of the LNG plant facilities is generated at the LNG plant site by means of Gas Turbine Generators.
S3328C6 Report	The Sonus report "Arrow LNG Plant – Noise and Vibration Impact Assessment", Ref. No. S3328C6, dated October 2011.

Sensitive receptor	A location in the vicinity of the proposed development, where noise may affect the amenity of the land use. For the proposed development, sensitive receptors are generally dwellings.
Sound power level	A measure of the sound energy emitted from a source of noise.
WHO	World Health Organisation.
Worst-case	Conditions resulting in the highest noise level at or inside dwellings. Worst-case meteorological conditions can be characterised as no cloud at night with wind from the project site to dwellings.

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1 INTRODUCTION

Sonus Pty Ltd (Sonus) has been engaged to conduct a supplementary noise and vibration impact assessment of the proposed Arrow LNG Plant (the project).

The assessment was commissioned to assess the potential changes to the noise and vibration impact of the project as a result of variation to the project description. The assessment specifically addresses project components that have been affected by changes and supplements the initial assessment conducted for the project.

The initial assessment, conducted by Sonus, is detailed in the report “Arrow LNG Plant – Noise and Vibration Impact Assessment”, Ref. No. S3328C6, dated October, 2011 (the S3328C6 Report). The S3328C6 Report was an appendix to the environmental impact statement (EIS) for the project, published in March 2012.

The supplementary assessment uses the method and criteria described in the S3328C6 Report to assess the noise and vibration impact of the proposed changes to the project. This supplementary assessment will form part of the Supplementary Report to the EIS being prepared for the project.

2 KEY CHANGES TO THE PROJECT DESCRIPTION

The key changes to the project description presented in the EIS are related to the LNG plant, feed gas pipeline and dredging activity. The changes have been reviewed and the following aspects are considered to be relevant to the noise and vibration impact assessment:

- **LNG plant layout:** The layout of the LNG plant on Curtis Island has changed including the area of disturbance on the site and adjacent to Boatshed Point (refer Figure A.1 in Appendix A).
- **Power generation:** The base case (preferred option) is the all mechanical option referred to in the EIS (also known as Power Island Mode). The alternate case is now a hybrid mechanical/electrical option (also known as Partial Auxiliary Power Import Mode). The all electrical option has been discontinued. Power generation and LNG plant ancillary infrastructure has been rearranged with the power generation facility relocated from the east side of the LNG trains to the west side of the trains (refer Figure C.1 in Appendix C).
- **Noise data**: As a consequence of the power generation and LNG plant ancillary infrastructure being rearranged on the site, the main noise sources and the associated sound power levels have been updated as per the report "Arrow LNG Plant Project - Environmental Noise Study Report", Doc. No. LNGF-003-GE00-AA-8380-00002, dated 8th May, 2012 (the FEED Noise Report), prepared by the FEED Contractor.
- **Construction**: Additional information on construction machinery, plant and equipment and excavation volumes has been provided. The information includes the required equipment and the estimated total number of units required for each type of equipment for the construction on Curtis Island.
- **Dredging activity:** Two new dredge sites have been included in the project description; an access channel from the Targinie Channel to the Boatshed Point Material Offloading Facility (MOF) and a swing basin and enlarged access area around the Boatshed Point MOF.

3 ASSESSMENT CRITERIA

The appropriate assessment criteria for the project were outlined in the S3368C6 Report and have been directly adopted in this assessment.

The assessment criteria were developed based on the requirements and recommendations of the relevant legislation and guidelines. These legislation and guidelines, and the proposed assessment criteria are provided below.

It is noted that the noise criteria have been specified at selected assessment locations (AL), which are representative of the closest noise sensitive receptors to the project (refer Figure A.2 in Appendix A) and defined in the S3368C6 Report. Achieving the criteria at the ALs will ensure compliance at all other noise sensitive receptors.

3.1 Legislation and Guidelines

The legislation and guidelines relevant to the establishment of appropriate noise and vibration assessment conditions are listed below.

Noise

- the *Environmental Protection Act 1994;*
- the Environmental Protection (Noise) Policy 2008;
- World Health Organization (WHO) Guidelines 1999; and
- Department of Environment and Resource Management (DERM) "Assessment of Low Frequency Noise" Draft Guideline 2002.

Vibration

- Australian Standard AS 2670.2-1990 "Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock induced vibration in buildings (1 to 80 HZ)"; and
- German Standard DIN 4150.3-1999 "Structural Vibration – Part 3: Effect of vibration on structures".

3.2 Noise

The operational and construction noise criteria developed for the project which are relevant to this assessment are summarised in Table 3.1. The assessment meteorological conditions are also included in the table.

Table 3.1: Summary of proposed noise criteria.

Activity	Source	Assessment Location	Outdoor Noise Criterion (dB(A))			Assessment Meteorological Conditions
			Day[1]	Evening[2]	Night[3]	
Operation	LNG plant	AL 1	33			Neutral (CONCAWE Category 4)
		AL 6				
		AL 3	33			Worst-case (CONCAWE Category 6)
		AL 2	28			
		AL 4	28			Neutral (CONCAWE Category 4)
		AL 5				
Construction	LNG plant Marine facilities Feed gas pipeline Dredging	AL 1	*All reasonable and practicable measures to reduce the noise impact*		40[4]	Neutral (CONCAWE Category 4)
		AL 2				
		AL 3				
		AL 4				
		AL 5				
		AL 6				

Notes:

1. Daytime is 7am to 6pm.
2. Evening is 6pm to 10pm.
3. Night-time is 10pm to 7am.
4. Criterion reduced from 45 dB(A) to 40 dB(A) as agreed with Department of Environment and Heritage Protection (DEHP).

3.3 Vibration

The established vibration level limits relate to two vibration components; human comfort and structural damage. The limits are provided in terms of the human threshold for perception, the short-term and long-term acceptable levels for dwellings and the acceptable levels for underground pipework. These limits are provided in Tables 3.2, 3.3, 3.4 and 3.5, respectively.

Table 3.2: Magnitudes of vibration that approximate human threshold for perception – AS 2670.2-1990.

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

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

Table 3.3: Short-term acceptable vibration levels for dwellings - DIN 4150.3-1999.

Vibration Level (mm/s)			
At the foundation of the dwelling			At horizontal plane of highest floor of dwelling
1 to 10 Hz	10 to 50 Hz	Above 50 Hz	
5	5 to 15	15 to 20	15

Table 3.4: Long-term acceptable vibration levels for dwellings - DIN 4150.3-1999.

Location	Vibration level (mm/s) at all frequencies
Horizontal plane of the highest floor of dwelling	5

Table 3.5: Acceptable vibration levels for underground pipework - DIN 4150.3-1999.

Pipework material	Vibration level (mm/s) measured on the pipe
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

The components and vibration level limits applicable for the construction and operation of the project are as follows:

Construction

- Structural damage – short-term vibration levels (Table 3.3);
- Underground pipework and telecommunication lines – vibration levels (Table 3.5);

Operation

- Human comfort – threshold of human perception (Table 3.2);
- Structural damage – long-term vibration levels (Table 3.4); and,
- Underground pipework and telecommunication lines – vibration levels (Table 3.5).

4 NOISE IMPACT ASSESSMENT

The assessment has been conducted in accordance with the method described in the S3328C6 Report. The assessment considers components of the project that have the potential to change the noise impact of the project as a result of the variation to the project description described in Section 2. For components that are not affected by the variation, an assessment has not been made, and the noise impact remains as determined in the S3368C6 Report.

4.1 Operational Noise

The assessment of operational noise specifically considers the noise impact from the revised power option arrangements and the updated plant main noise sources, associated sound power levels and layout.

4.1.1 Noise Sources

The assessment considers two power generation cases; the base case, which is the all mechanical option and the alternate case, which is the mechanical/electrical option.

The main noise sources and the associated sound power levels and locations have been based on the FEED Noise Report. The main noise sources, the quantity of each source and the total sound power levels are summarised in Tables 4.1 and 4.2. Appendix B provides the octave band sound power levels for all of the considered noise sources. Appendix C provides the revised layout of the LNG plant.

Table 4.1: All mechanical option - Main noise sources and sound power levels without additional acoustic treatment.

Noise Source	Quantity	Total Sound Power Level (dB(A))
Process Train Equipment (per train)		
Air Cooled Heat Exchangers		
Fan	312	89
Main Refrigerant Compressor String		
Gas turbine with enclosure	2	103
MR compressor	2	101
Suction piping – MR compressor	2	110
Discharge piping – MR compressor	2	82
C3 compressor	2	101
Suction piping – C3 compressor	2	116
Discharge piping – C3 compressor	2	80
HTIC	2	94
Inlet filter	2	95
Exhaust stack	2	100
Regeneration Gas Compressor String		
Regeneration gas compressor	1	98
Gear	1	85
Motor	1	102
End Flash Gas Compressor String		
EFG compressor	1	104
Motor	1	98
Gear	1	91
L/O unit	1	103
Suction piping – EFG compressor	1	112
Discharge piping – EFG compressor	1	100
LNG hydraulic turbine pot mount case	1	100
Lean solvent main charge pump	2	90
Motor – lean solvent main charge pump	2	90
Lean solvent booster pump	2	99
Motor – lean solvent booster pump	2	97
Regenerator reflux pump	1	88
Motor – regenerator reflux pump	1	95
LNG rundown pump	1	100
Motor – LNG rundown pump	1	100
Hot water pump	2	100
Motor – hot water pump	2	99
Process control valve	97	65

Table 4.1: All mechanical option - Main noise sources and sound power levels without additional acoustic treatment (continued).

Noise Source	Quantity	Total Sound Power Level (dB(A))
Common Equipment for Trains 1 and 2		
Air Cooled Heat Exchangers		
Fan	36	89
Gas Turbine Generators		
Generator	4	103
Gas turbine with enclosure	4	96
Air filter	4	100
Gear box	4	103
Exhaust	4	90
Mineral oil to air cooler	4	90
BOG Compressor String		
BOG compressor LP	1	99
BOG compressor HP	1	90
Motor	1	106
Gear	1	103
L/O unit	1	95
Suction piping – BOG compressor	1	105
Discharge piping – BOG compressor	1	94
Instrument air compressor package	1	103
Motor – instrument air compressor package	1	102
Nitrogen compressors	1	103
Motor – nitrogen compressor	1	98
Cooling water circulation pump	3	92
Motor – cooling water circulation pump	3	89
LP demineralised water pump	1	88
Motor – LP demineralised water pump	1	95
Diesel supply pump	1	88
Motor – diesel supply pump	1	95
Jockey pump	1	96
Motor – jockey pump	1	97
Feed pump	1	91
Motor – feed pump	1	96
Air dryer package	1	95
Motor – air dryer package	1	92
Process control valve	56	68
Common Equipment for Trains 3 and 4		
Air-cooled Heat Exchangers		
Fan	36	89

Table 4.1: All mechanical option - Main noise sources and sound power levels without additional acoustic treatment (continued).

Noise Source	Quantity	Total Sound Power Level (dB(A))
Gas Turbine Generators		
Generator	3	103
Gas turbine with enclosure	3	96
Air filter	3	100
Gear box	3	103
Exhaust	3	90
Mineral oil to air cooler	3	90
BOG Compressor String		
BOG compressor LP	1	99
BOG compressor HP	1	90
Motor	1	106
Gear	1	103
L/O unit	1	95
Suction piping – BOG compressor	1	105
Discharge piping – BOG compressor	1	94
Instrument air compressor package	1	103
Motor – instrument air compressor package	1	102
Nitrogen compressors	1	103
Motor – nitrogen compressor	1	98
Cooling water circulation pump	3	92
Motor – cooling water circulation pump	3	89
LP demineralised water pump	1	88
Motor – LP demineralised water pump	1	95
Diesel supply pump	1	88
Motor – diesel supply pump	1	95
Jockey pump	1	96
Motor – jockey pump	1	97
Feed pump	1	91
Motor – feed pump	1	96
Air dryer package	1	95
Motor – air dryer package	1	92
Process control valve	56	65

Table 4.2: Mechanical/electrical option - Main noise sources and sound power levels without additional acoustic treatment.

Noise Source	Quantity	Total Sound Power Level (dB(A))
Process Train Equipment (per train)		
Equipment as per all mechanical drive option provided in Table 4.1		
Common Equipment for Trains 1 and 2		
Gas Turbine Generators		
Generator	2	103
Gas turbine with enclosure	2	96
Air filter	2	100
Gear box	2	103
Exhaust	2	90
Mineral oil to air cooler	2	90
All other equipment as per all mechanical drive option provided in Table 4.1		
Common Equipment for Trains 3 and 4		
Gas Turbine Generators		
Generator	2	103
Gas turbine with enclosure	2	96
Air filter	2	100
Gear box	2	103
Exhaust	2	90
Mineral oil to air cooler	2	90
All other equipment as per all mechanical drive option provided in Table 4.1		

4.1.2 Noise Predictions

The noise from the operation of the LNG plant at the assessment locations has been predicted using the CONCAWE noise propagation model[1] in the SoundPlan noise modelling software. The predictions were made under the established meteorological conditions, indicated in Table 3.1.

The predicted noise level at each assessment location for the power option cases is summarised in Table 4.3. Noise contours of the predicted noise levels under neutral (Category 4) and worst-case (Category 6) meteorological conditions are provided in Appendix D.

[1] The CONCAWE propagation model takes into account topography, ground absorption, air absorption and meteorological conditions, and is widely accepted around the world as an appropriate sound propagation model. The model is described further in the S3328C6 Report.

Table 4.3: Predicted noise levels from operation of the LNG plant without additional acoustic treatment.

Assessment Location	Meteorological Conditions Category	Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			All Mechanical		Mechanical/Electrical	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	33	37	38	36	38
AL 2	6 (Worst-case)	28	12	15	12	15
AL 3	6 (Worst-case)	33	22	24	21	24
AL 4	4 (Neutral-case)	28	24	27	24	27
AL 5	4 (Neutral-case)	28	18	21	18	21
AL 6	4 (Neutral-case)	33	35	37	35	37

The predictions indicate that the operational noise level at AL 1 and AL 6 will exceed the noise criterion for both power option modes, without additional acoustic treatment being applied.

4.1.3 Mitigation Measures

In order to achieve the noise criteria for the operation of the LNG plant at the noise sensitive receptors, additional acoustic treatment will be required to be incorporated during the detailed design stage of the project.

Potential additional acoustic treatment considered for the project includes:

(i) redesigning the Air Cooled Heat Exchangers (ACHE) to achieve further sound power level reduction of 10 dB;

(ii) upgrading the process gas turbine enclosure construction; and,

(iii) enclosing pumps (including driving motor) - lean solvent booster pumps, hot water pumps and LNG rundown pumps.

The above additional acoustic treatment has been incorporated in the noise model based on the noise reduction provided in Table 4.4.

Table 4.4: Minimum noise reduction from additional acoustic treatment.

Noise Source	Minimum Noise Reduction (dB(A)) by Octave band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
ACHE	10	10	10	10	10	10	10	10
Process gas turbine enclosure	0	0	3	5	0	0	0	0
Pumps (lean solvent booster, hot water and LNG rundown pumps)	10	10	10	10	10	10	10	10

With the above acoustic treatment incorporated in the design, the predicted noise levels at the ALs under the relevant meteorological conditions for both power option arrangements are summarised in Table 4.5. Noise contours of the predicted noise levels under neutral (Category 4) and worst-case (Category 6) meteorological conditions with additional acoustic treatment are provided in Appendix E.

Table 4.5: Predicted operational noise levels with additional acoustic treatment.

Assessment Location	Meteorological Conditions Category	Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			All Mechanical		Mechanical/electrical	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	33	34	36	34	35
AL 2	6 (Worst-case)	28	8	10	7	10
AL 3	6 (Worst-case)	33	18	20	17	20
AL 4	4 (Neutral-case)	28	20	23	20	23
AL 5	4 (Neutral-case)	28	14	17	14	17
AL 6	4 (Neutral-case)	33	32	33	31	33

The predictions indicate that the operational noise level at all assessment locations will achieve the relevant noise criterion with acoustic treatment incorporated, except at AL 1.

To achieve the noise criterion at AL 1, further acoustic treatment will be required, in addition to that considered above. The potential acoustic treatment includes upgrading the construction of process compressor enclosures; upgrading the construction of power generation unit enclosures; upgrading the silencer to gas the turbine exhaust stack; and enclosing the remaining pumps (including associated motors).

4.1.4 Low Frequency Noise

The low frequency noise level inside the two closest dwellings at AL 1 and AL 6 has been predicted under neutral meteorological conditions with the additional acoustic treatment incorporated. The prediction assumes a noise reduction of 10 dB(A) from outside to inside of the dwelling which is a conservative estimate. The predicted noise level is provided in Table 4.6.

Table 4.6: Predicted low frequency noise levels (operation) with additional acoustic treatment.

Assessment Location	Meteorological Conditions Category	Indoor Noise Criterion, dB(A)	Predicted Operational Noise Level, dB(A)			
			All Mechanical		Mechanical/Electrical	
			2 Trains	4 Trains	2 Trains	4 Trains
AL 1	4 (Neutral-case)	20	14	16	14	16
AL 6	4 (Neutral-case)	20	13	15	13	15

The predictions indicate that the low frequency noise level inside the two dwellings will be no greater than 16 dB(A) with the recommended acoustic treatment for any power option arrangement, therefore achieving the 20 dB(A) low frequency noise level ($L_{pA,LF}$) criterion of the DERM Low Frequency Noise Draft Guideline.

4.2 Construction Noise

The construction equipment information provided as a part of the project description changes includes details of the machinery, equipment and vehicles required for construction on Curtis Island and the number of each item during the construction phase.

As the information is consistent with the assumptions considered in the initial assessment, the noise impact and mitigation requirements provided in the S3328C6 Report for construction noise remain valid.

4.2.1 Dredging

Additional dredging has been proposed at two of the original dredge sites; Dredge Site 3 near Boatshed Point and Dredge Site 5 near the LNG Jetty (refer Figure C.1 in Appendix C). The noise from the dredging activity at these two sites has been re-assessed as the distance to some sensitive receivers has reduced.

The main noise sources during dredging activities at each site have been determined based on the proposed equipment and the extended area of dredging. The equipment and the associated maximum sound power levels are summarised in Table 4.7.

Table 4.7: Main noise sources at dredge sites.

Noise Source	Maximum Overall Sound Power Level (dB(A))	Number at Each Dredge Site	
		Dredge Site 3 Boatshed Point	Dredge Site 5 LNG Jetty
Small CSD	106	1	1
Backhoe(BH)	118	1	1
Tug boat	111	1	1
Barge	104	1	1

Based on the equipment and sound power levels provided in Table 4.7, the noise level at the assessment location has been predicted under neutral meteorological conditions. The prediction assumes a "worst-case" period of all equipment operating simultaneously and continuously at the respective dredging sites. The predicted noise levels are provided in Table 4.8.

Table 4.8: Predicted noise levels from dredging.

Dredge Site	Predicted Noise Level (dB(A)) at each Assessment Location					
	AL 1	AL 2	AL 3	AL 4	AL 5	AL 6
Dredge Site 3 - Boatshed Point	54	16	27	30	25	45
Dredge Site 5 - LNG Jetty	32	14	25	24	21	30

Based on the prediction, the noise from dredging activity at both dredge sites achieves the criterion of 40 dB(A) at all assessment locations, except at AL 1 and AL 6 for dredging at Dredge Site 3. Therefore, mitigation measures will be required in order to achieve the criterion. These measures might include scheduling of the dredging closest to AL1 and AL6 such that it occurs at the least sensitive time of day.

5 VIBRATION IMPACT ASSESSMENT

The changes to the project description have not resulted in significant changes to the type of equipment (i.e., vibration source) and the location (i.e., distance) of the equipment relative to the sensitive receptors. It is noted that although the dredging at Dredge Site 3 (Boatshed Point) has moved closer to some sensitive receptors, the reduced distance does not change the assessment outcomes as the change in distance is small relative to the total distance.

Therefore, the vibration impact at sensitive receptors (including underground pipework and telecommunication lines) as determined in the initial assessment does not change. That is, the conclusions for the vibration impact assessment in the S3328C6 Report remain valid

6 CUMULATIVE IMPACT ASSESSMENT

The cumulative noise and vibration impact assessment takes into account the noise and vibration impact of the project, existing developments, and projects that have been approved by the Queensland Coordinator-General by proposing noise conditions at the closest sensitive receptors that are 10 dB(A) more stringent than the requirements of the EPP (Noise). This allows similar noise contributions from up to 10 other projects while still achieving the criteria outlined in the EPP (Noise).

The noise and vibration impact assessments outlined in Sections 4 and 5, respectively, determined that the noise and vibration impact of the project remains largely unchanged from that determined in the initial assessment. On this basis, the conclusions for the cumulative impact assessment in the S3328C6 Report remain valid.

7 CONCLUSION

This supplementary assessment has considered the potential change to environmental noise and vibration impact from the operation and construction of the LNG plant and associated infrastructure, with the proposed project description changes.

The assessment maintained the method and criteria developed in the initial noise and vibration impact assessment, summarised in the S3328C6 Report. The assessment determined the noise and vibration impact for project components which are affected by the changes to the project description. For project components which are unaffected, the impacts and conclusion provided in the S3328C6 Report remain valid.

Based on predictions, the noise conditions will be achieved at the noise sensitive receptors with a feasible level of acoustic treatment applied to equipment at the LNG plant.

The construction equipment information provided is consistent with the assumptions considered in the initial assessment, therefore the noise impact and mitigation requirements provided in the S3328C6 Report for construction noise remain valid.

Prediction of the noise from dredging activity at the additional dredge sites indicates that the noise level at noise sensitive receptors will achieve the established criteria.

The vibration impact from the project as determined in the initial assessment remains valid considering that the main factors which control vibration impact, such as the type of vibration source (i.e., type of equipment) and distance from the sensitive receptors, have not varied significantly with the changes to the project description.

As the noise and vibration impact of the project has remained largely unchanged with the changes to the project description, the conclusions for the cumulative impact assessment in the S3328C6 Report remain valid.

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APPENDIX A: SITE LOCALITY AND ASSESSMENT LOCATIONS

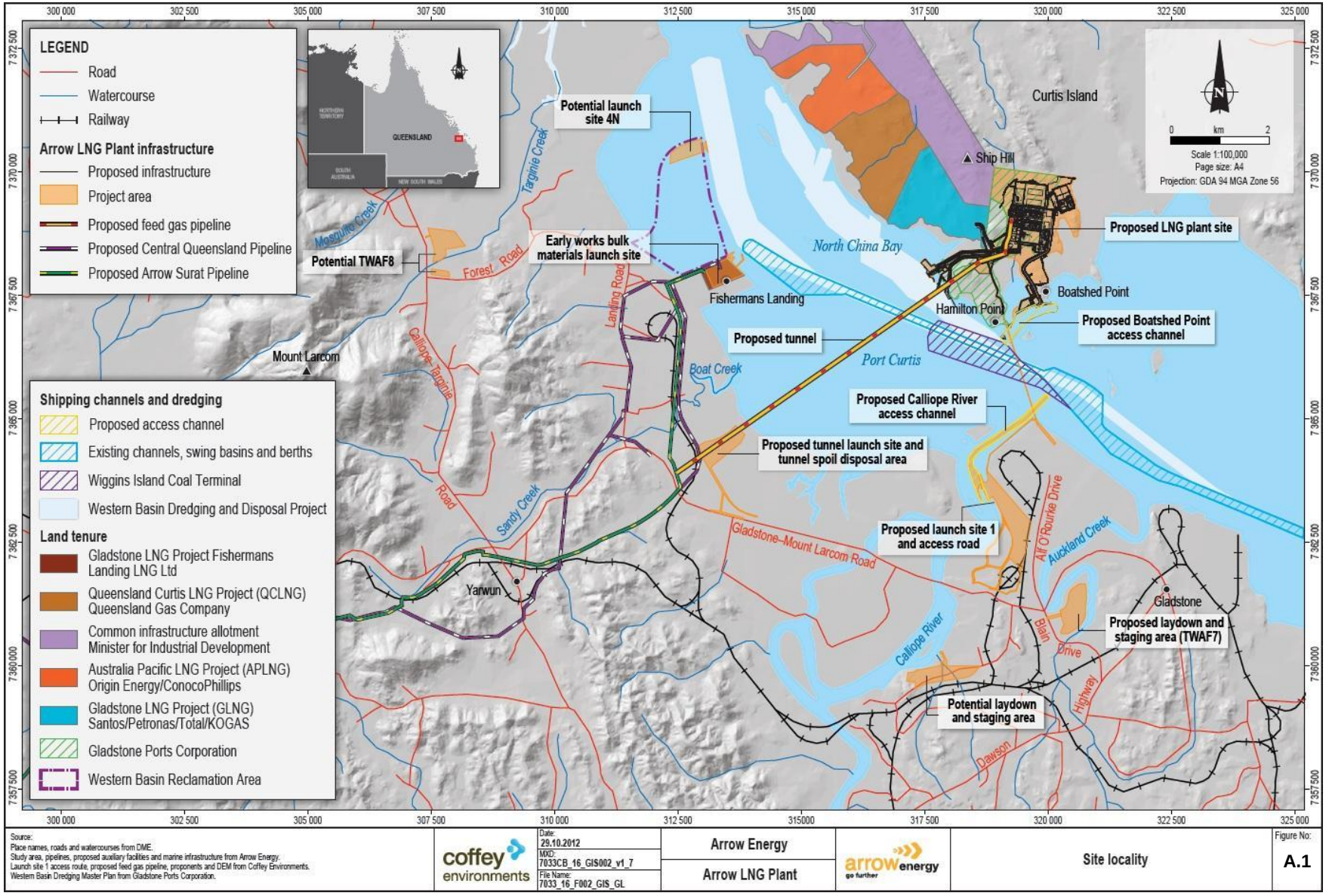


Figure A.1: Site locality.

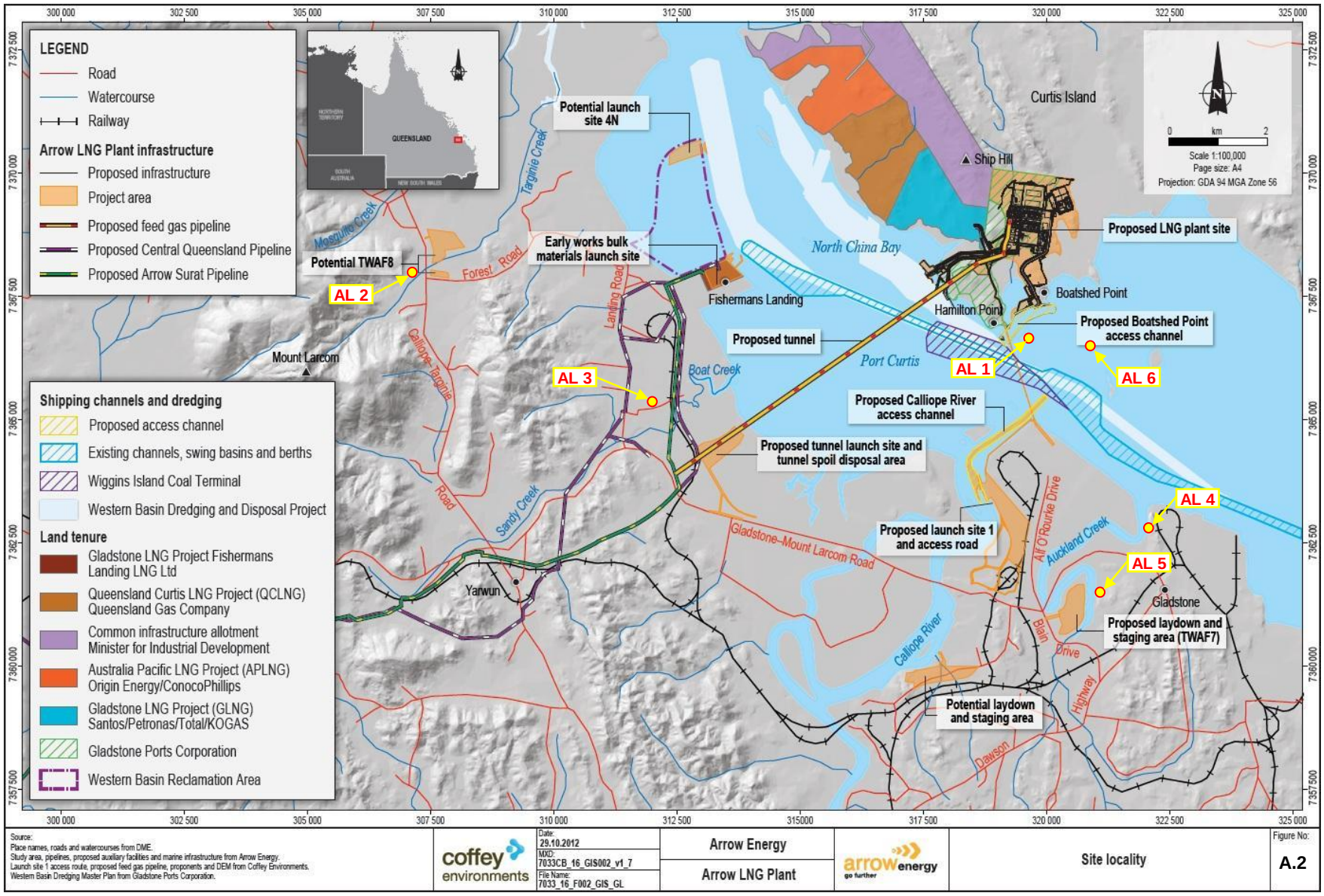


Figure A.2: Assessment locations.

APPENDIX B: LNG PLANT AND ASSOCIATED INFRASTRUCTURE LAYOUT

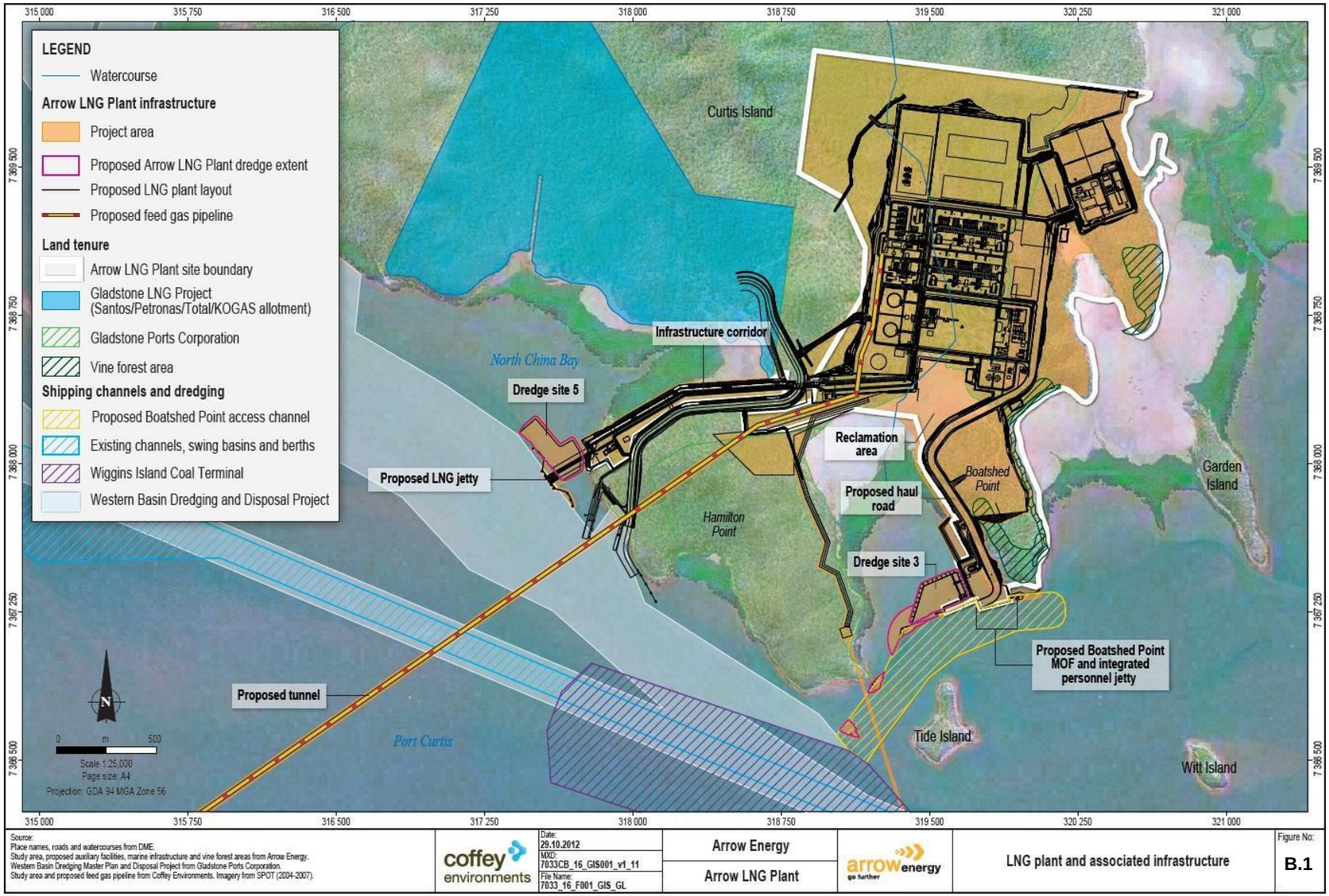


Figure B.1: LNG plant and associated infrastructure layout.

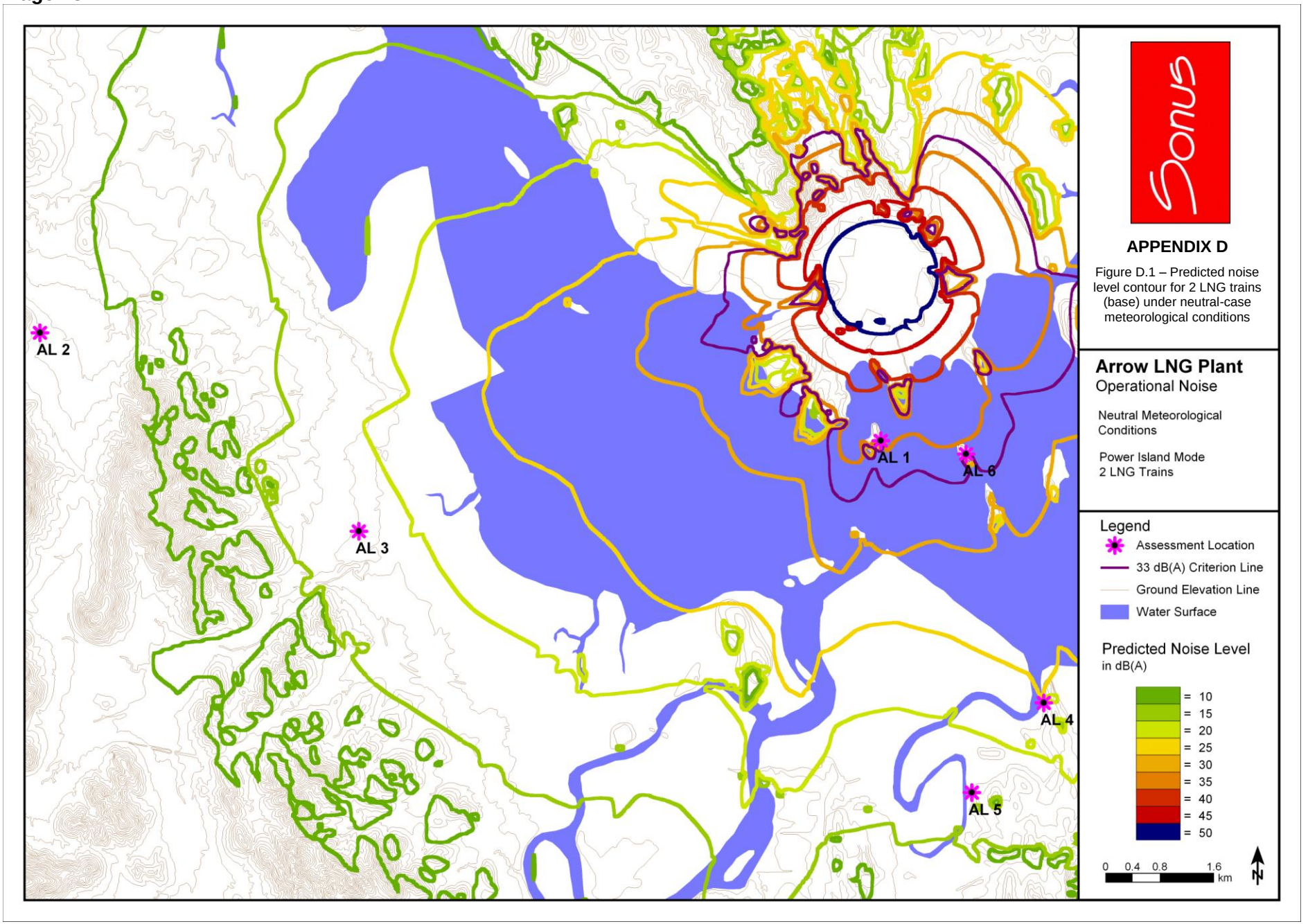
APPENDIX C: LNG PLANT MAIN NOISE SOURCES AND SOUND POWER LEVELS

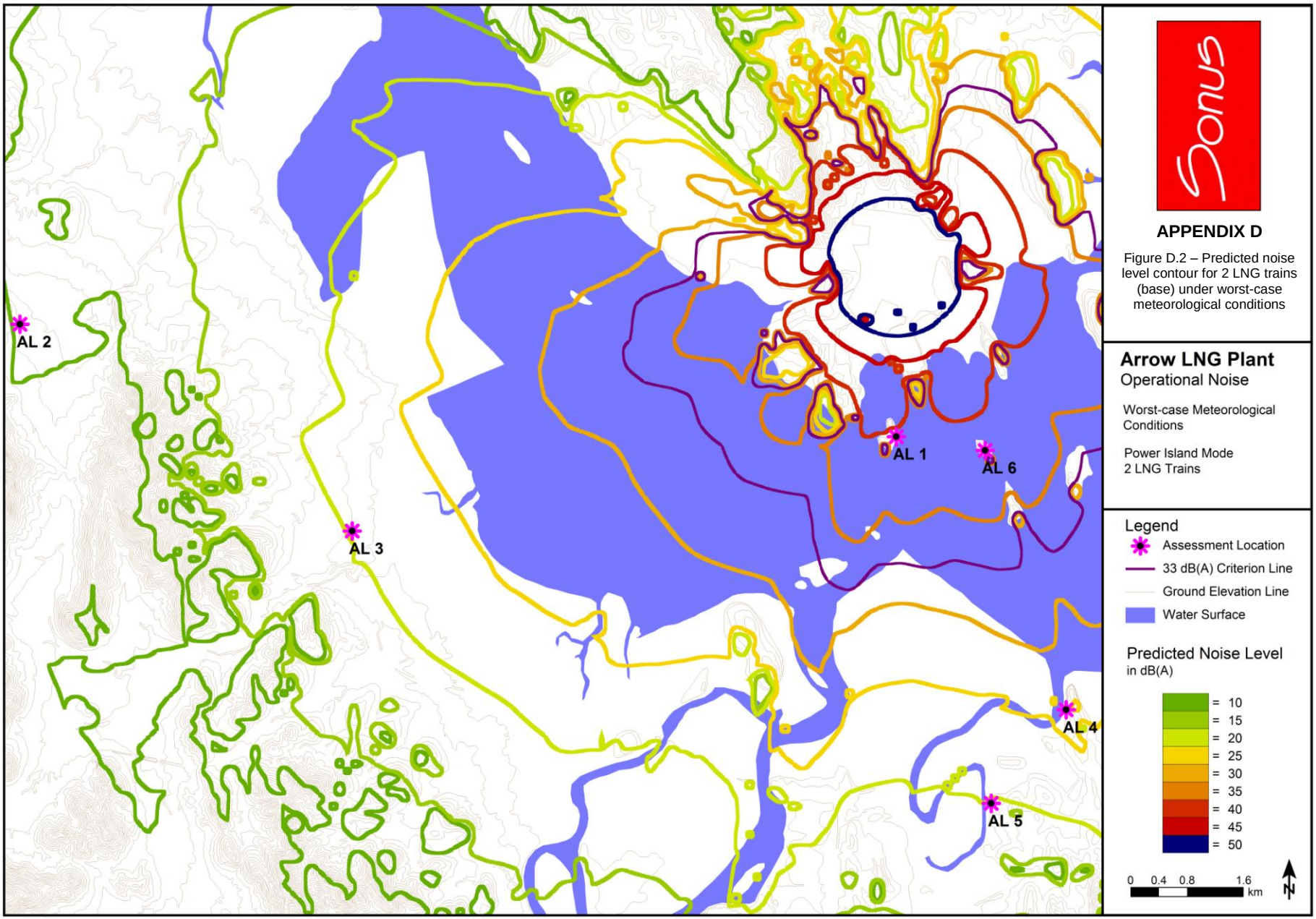
Table C.1: Sound power levels of the main noise sources.

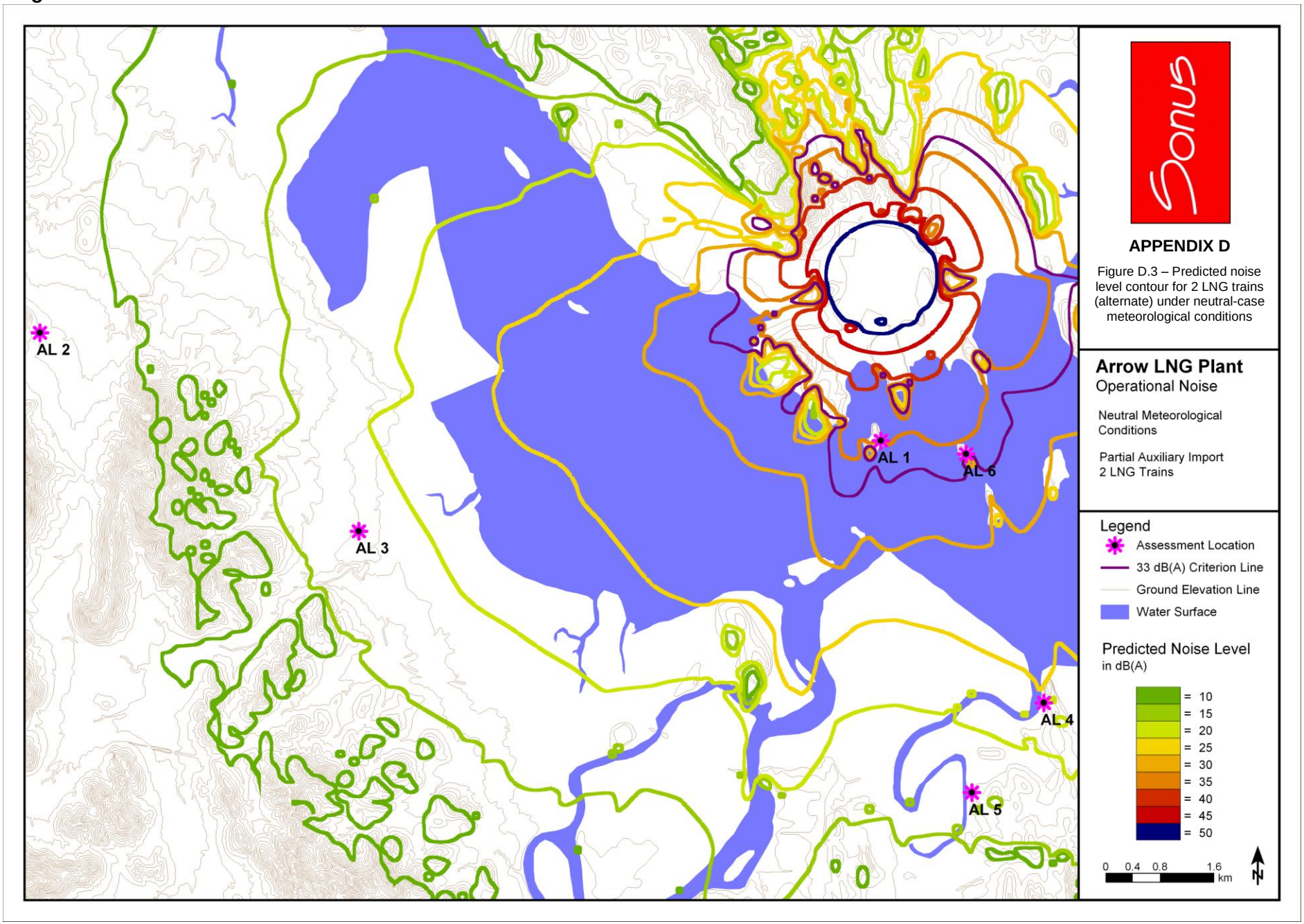
Noise Source	Maximum Sound Power Level (dB(A) re 1 pW) by Octave Band Frequency (Hz)								Total (dB(A))	Remarks
	63	125	250	500	1000	2000	4000	8000		
Process Train Equipment										
Air-cooled Heat Exchangers										
Fan	69	78	82	83	84	79	73	65	89	-
Main Refrigerant Compressor String										
Gas turbine with enclosure	79	89	98	99	94	92	89	65	103	Inside an enclosure
MR compressor	62	72	92	91	98	96	92	84	101	Inside an enclosure
Suction piping – MR compressor	74	79	85	90	94	107	105	96	110	With acoustic insulation
Discharge piping – MR compressor	61	68	74	74	69	73	77	69	82	With silencer and acoustic insulation
C3 compressor	60	70	82	91	98	96	92	84	101	Inside an enclosure
Suction piping – C3 compressor	79	85	90	96	100	113	111	102	116	With acoustic insulation
Discharge piping – C3 compressor	58	66	72	72	67	71	75	67	80	With silencer and acoustic insulation
HTIC	45	68	81	87	91	86	80	70	94	Inside an enclosure
Inlet filter	77	72	76	75	79	93	90	81	95	Based on larger filter
Exhaust stack	79	86	92	92	87	91	95	87	100	With silencer
Regeneration Gas Compressor String										
Regeneration gas compressor	70	82	85	89	92	94	87	76	98	Noise Mastic applied
Gear	48	60	69	74	80	82	73	64	85	-
Motor	65	77	86	91	97	99	90	81	102	-
End Flash Gas Compressor String										
EFG compressor	73	87	91	92	96	100	97	91	104	Inside an enclosure
Motor	61	73	82	87	93	94	86	77	98	Inside an enclosure
Gear	54	66	75	80	86	88	79	70	91	Inside an enclosure
L/O unit	66	78	87	92	98	99	91	82	103	-
Suction piping – EFG compressor	76	81	87	92	96	109	107	98	112	With acoustic insulation
Discharge piping – EFG compressor	79	86	92	92	87	91	95	87	100	With silencer and acoustic insulation
LNG hydraulic turbine pot mount case	61	74	83	92	95	95	90	80	100	-
Lean solvent main charge pump	63	73	79	84	86	82	77	74	90	Inside an enclosure
Motor – lean solvent main charge pump	63	74	79	84	86	82	77	75	90	Inside an enclosure
Lean solvent booster pump	72	82	88	93	95	91	86	83	99	-
Motor – lean solvent booster pump	71	81	87	92	93	89	84	82	97	-
Regenerator reflux pump	62	72	77	83	84	80	75	73	88	-
Motor – regenerator reflux pump	69	79	85	90	91	87	82	80	95	-
LNG rundown pump	74	84	90	95	96	92	87	85	100	-
Motor – LNG rundown pump	74	84	89	95	96	92	87	85	100	-
Hot water pump	73	83	89	94	96	92	87	84	100	-
Motor – hot water pump	72	82	88	93	94	91	85	83	99	-
Process control valve	39	47	45	51	53	54	61	61	65	-
Common Equipment for Process Trains										
Air-cooled Heat Exchangers										
Fan	69	78	82	83	84	79	73	65	89	-
Gas Turbine Generators										
Generator	75	85	88	96	98	98	93	82	103	Inside an enclosure

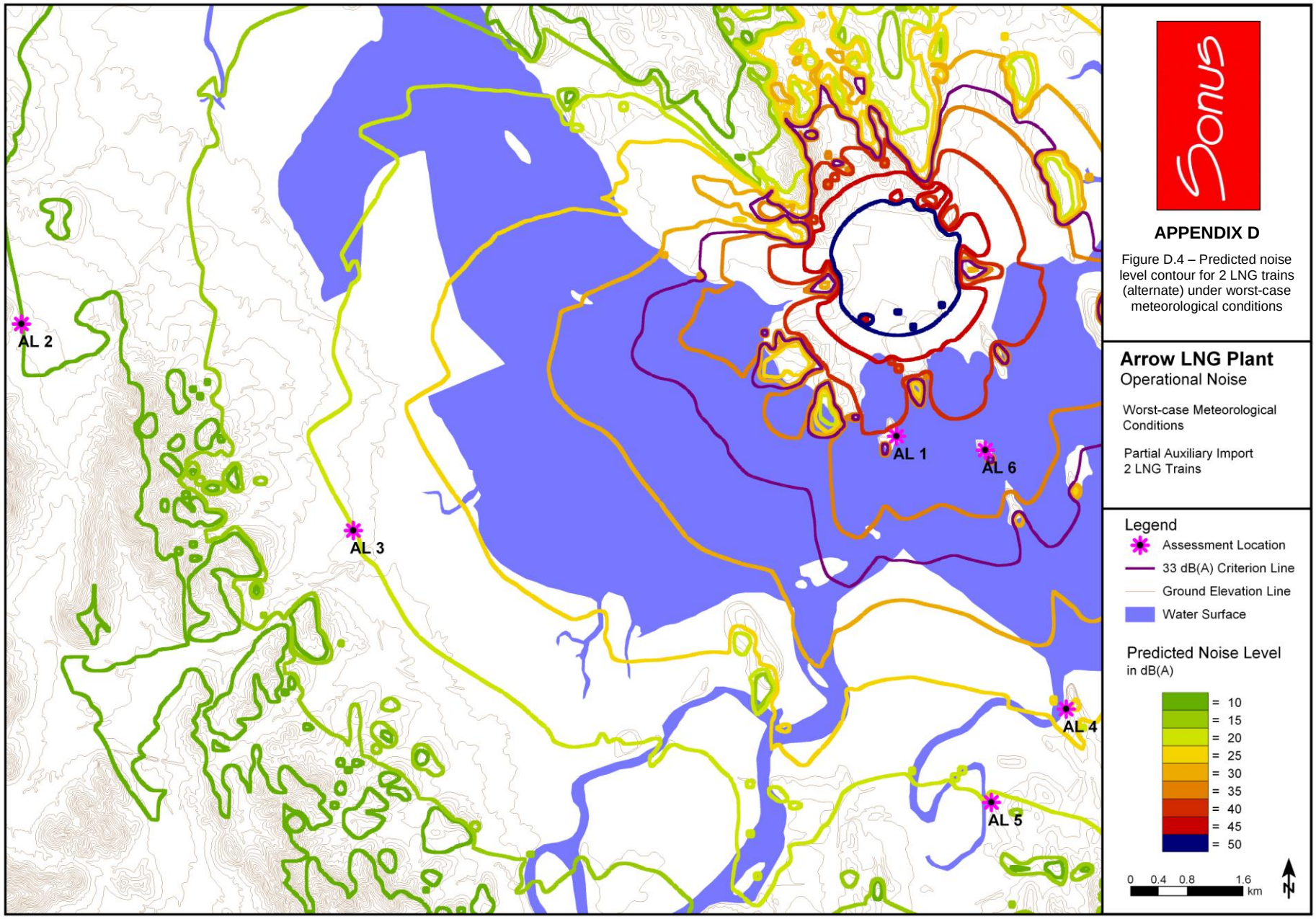
Noise Source	Maximum Sound Power Level (dB(A) re 1 pW) by Octave Band Frequency (Hz)								Total (dB(A))	Remarks
	63	125	250	500	1000	2000	4000	8000		
Gas turbine with enclosure	72	82	91	92	87	85	82	58	96	Inside an enclosure
Air filter	82	78	81	80	85	98	96	87	100	-
Gear box	77	88	95	93	96	96	96	92	103	-
Exhaust	69	76	82	82	77	81	85	77	90	With silencer
Mineral oil to air cooler	56	67	75	82	86	85	79	66	90	-
BOG Compressor String										
BOG compressor LP	71	83	86	90	93	95	88	77	99	Inside an enclosure
BOG compressor HP	62	74	77	81	84	86	79	68	90	Inside an enclosure
Motor	89	84	87	87	91	104	102	93	106	Inside an enclosure
Gear	85	80	83	83	87	100	98	89	103	Inside an enclosure
L/O unit	77	72	75	75	79	92	90	81	95	-
Suction piping – BOG compressor	69	74	80	85	89	102	100	91	105	With acoustic insulation
Discharge piping – BOG compressor	73	80	86	86	81	85	89	81	94	With silencer and acoustic insulation
Instrument air compressor package	84	90	92	97	99	96	90	81	103	Inside an enclosure
Motor – instrument air compressor package	79	87	92	96	96	95	89	79	102	Inside an enclosure
Nitrogen compressors	75	87	90	94	97	99	92	81	103	-
Motor – nitrogen compressor	70	82	85	89	92	94	87	76	98	-
Cooling water circulation pump	65	75	81	86	87	83	78	76	92	Inside an enclosure
Motor – cooling water circulation pump	63	73	78	84	85	81	76	74	89	Inside an enclosure
LP demineralised water pump	62	72	77	83	84	80	75	73	88	-
Motor – LP demineralised water pump	69	79	85	90	91	87	82	80	95	-
Diesel supply pump	62	72	77	83	84	80	75	73	88	-
Motor – diesel supply pump	69	79	85	90	91	87	82	80	95	-
Jockey pump	70	80	85	91	92	88	83	81	96	-
Motor – jockey pump	70	80	86	91	92	89	83	81	97	-
Feed pump	64	74	80	85	87	83	78	75	91	-
Motor – feed pump	69	79	85	90	91	88	82	80	96	-
Air dryer package	76	82	84	89	91	88	82	73	95	-
Motor – air dryer package	73	79	81	86	88	85	79	70	92	-
Process control valve	39	47	45	51	53	54	61	61	65	-

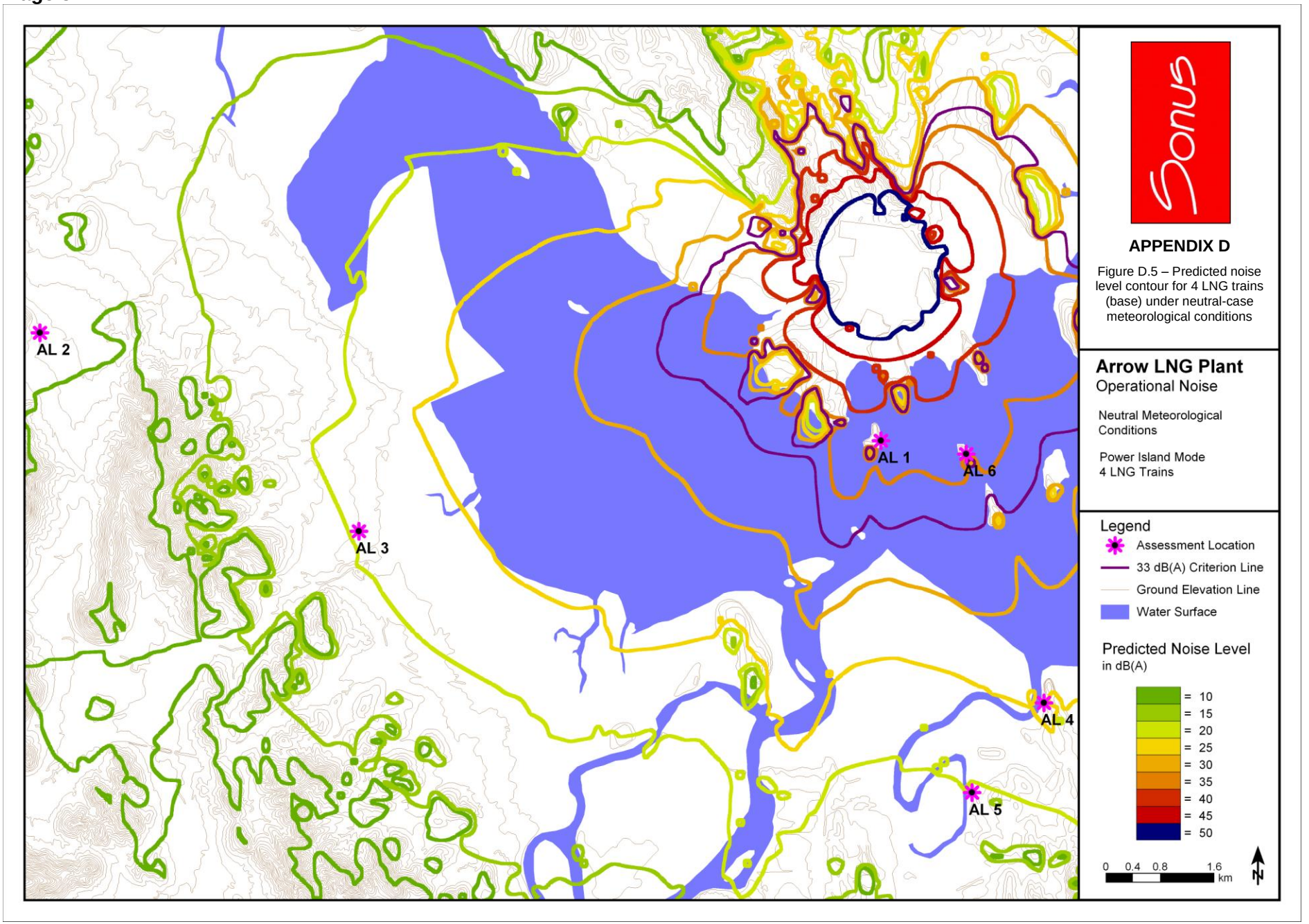
APPENDIX D: NOISE CONTOURS – WITHOUT ADDITIONAL ACOUSTIC TREATMENT

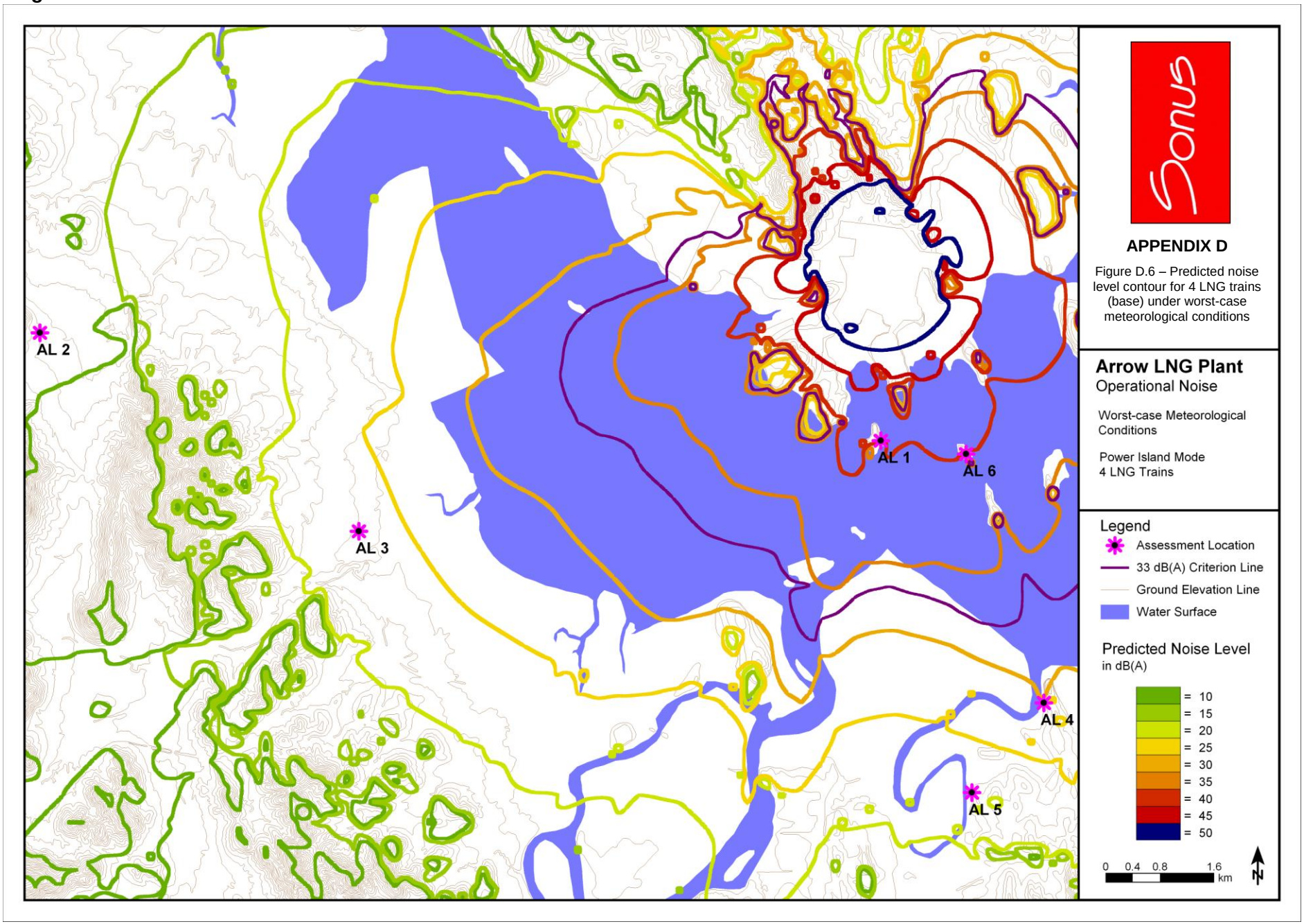

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.1 – Predicted noise level contour for 2 LNG trains (base) under neutral-case meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Power Island Mode
2 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

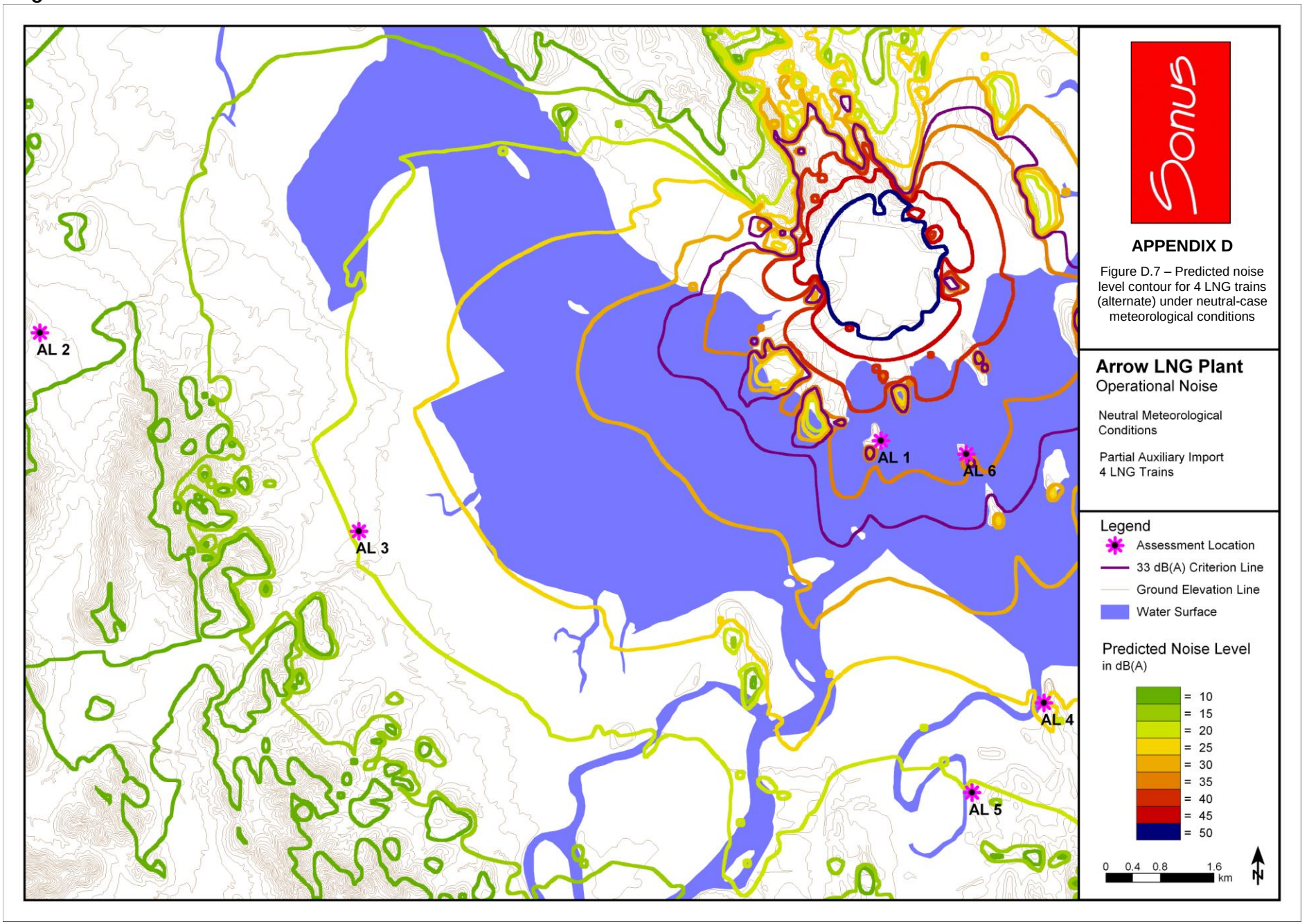

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.2 – Predicted noise level contour for 2 LNG trains (base) under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Power Island Mode
2 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

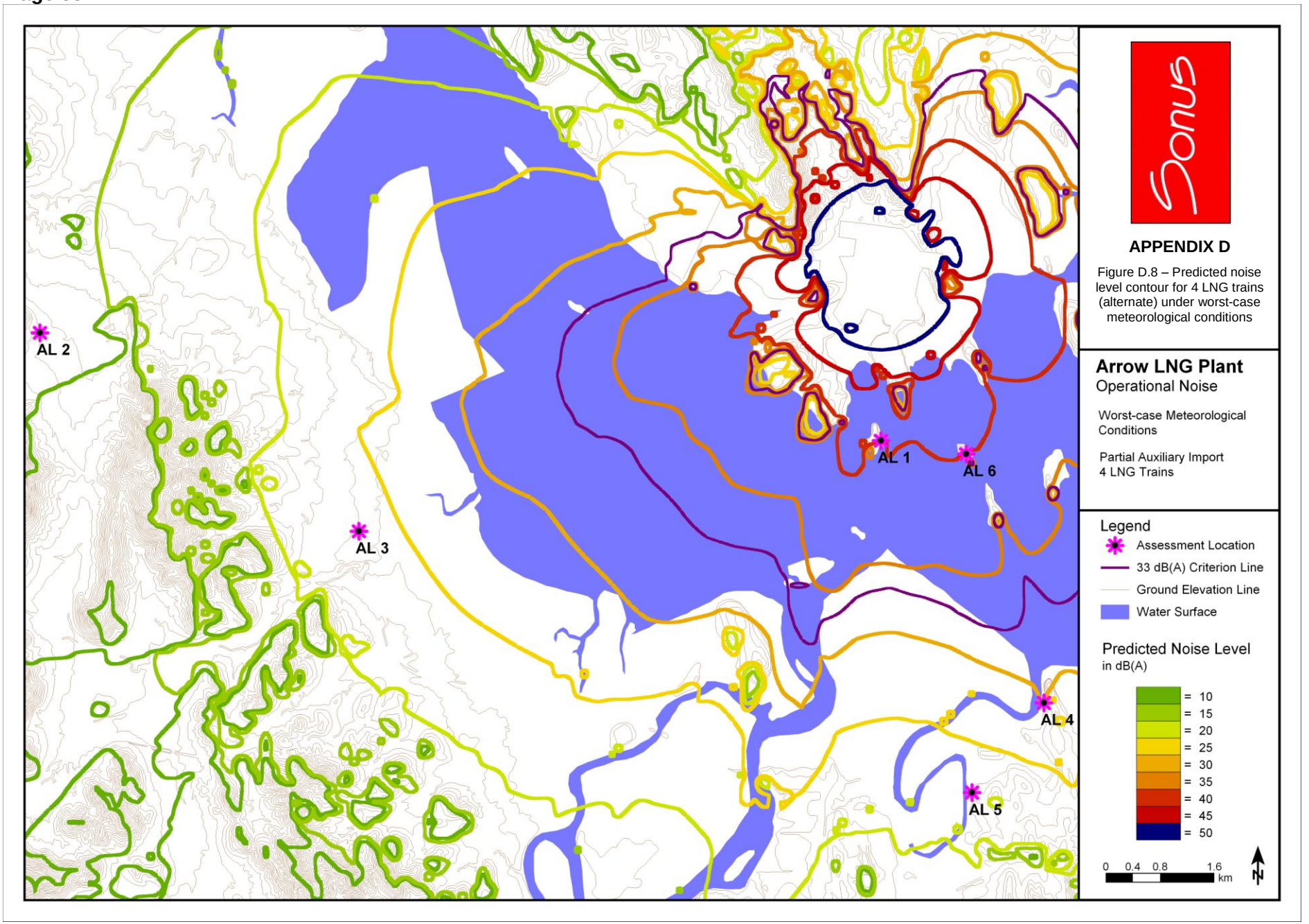

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.3 – Predicted noise level contour for 2 LNG trains (alternate) under neutral-case meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Partial Auxiliary Import
2 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.4 – Predicted noise level contour for 2 LNG trains (alternate) under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Partial Auxiliary Import
2 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

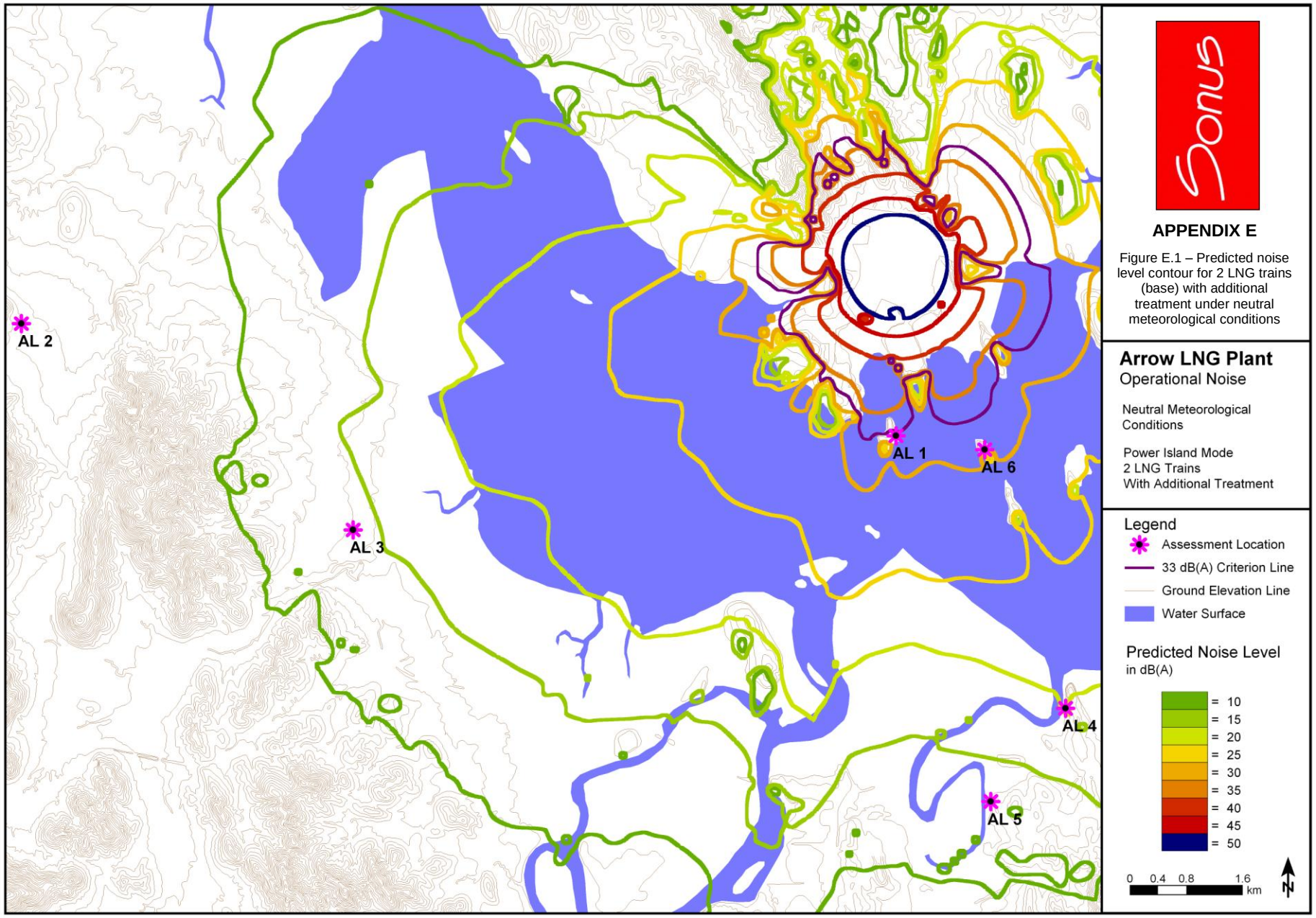

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.5 – Predicted noise level contour for 4 LNG trains (base) under neutral-case meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Power Island Mode
4 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

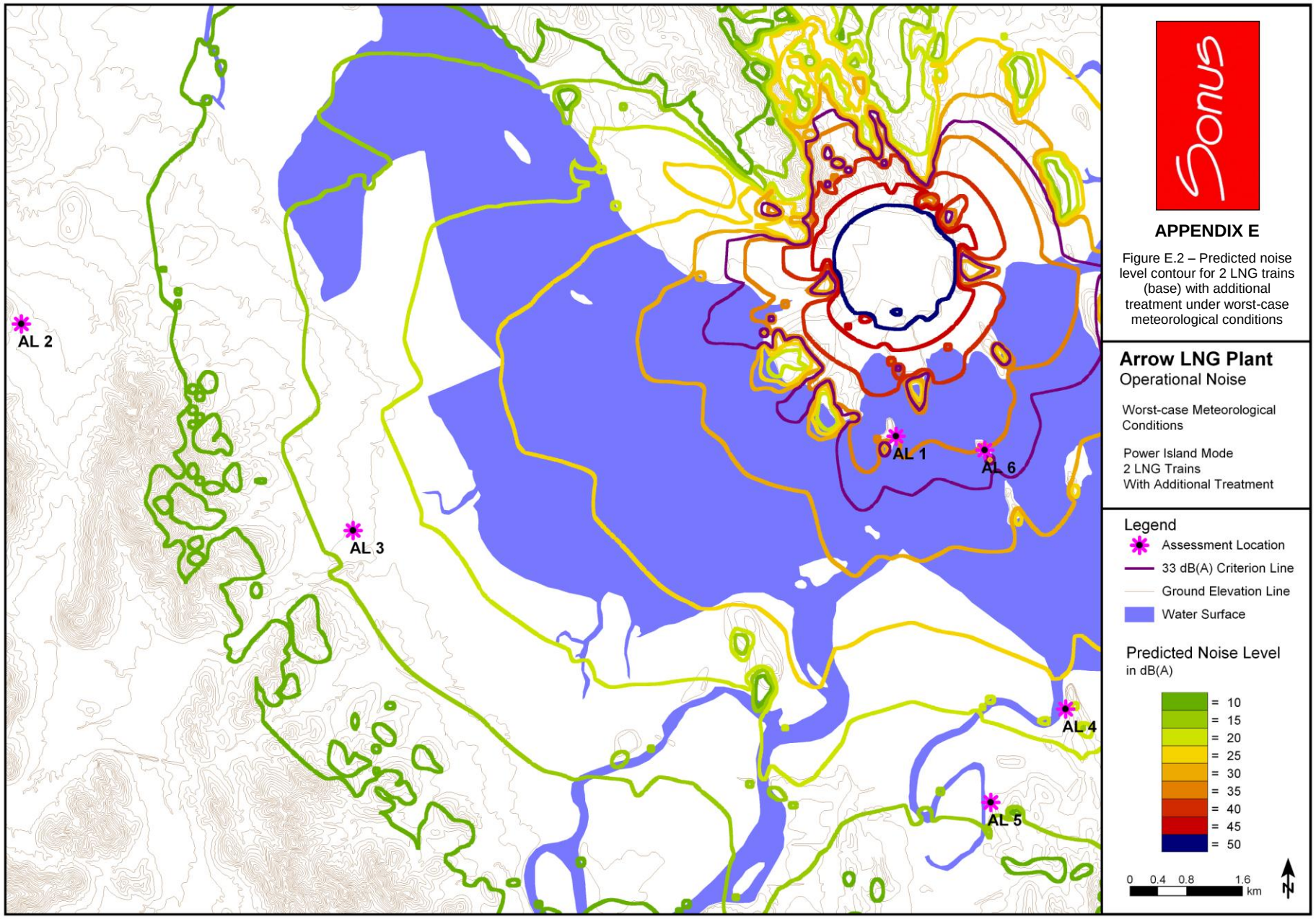

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.6 – Predicted noise level contour for 4 LNG trains (base) under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Power Island Mode
4 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

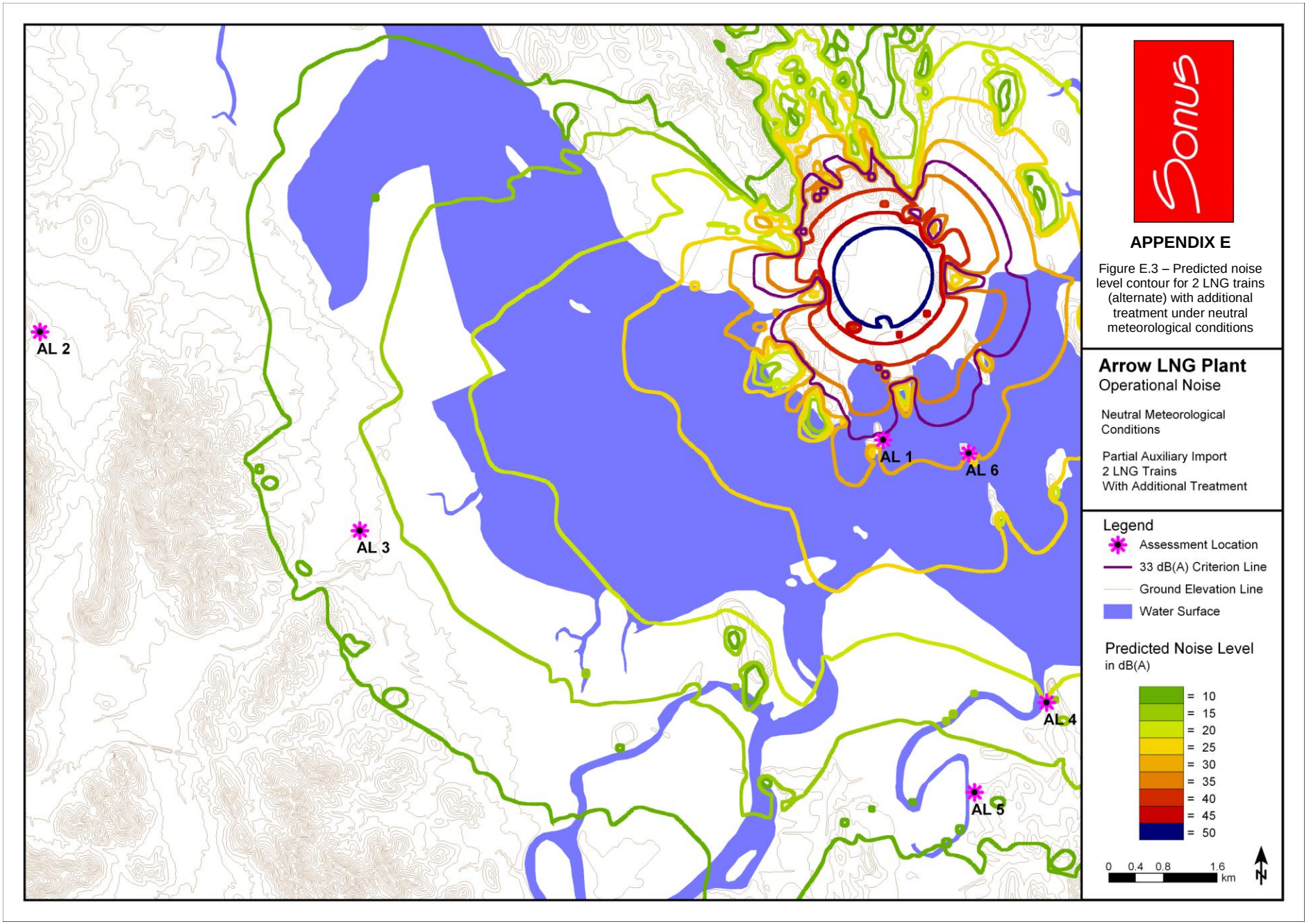

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.7 – Predicted noise level contour for 4 LNG trains (alternate) under neutral-case meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Partial Auxiliary Import
4 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

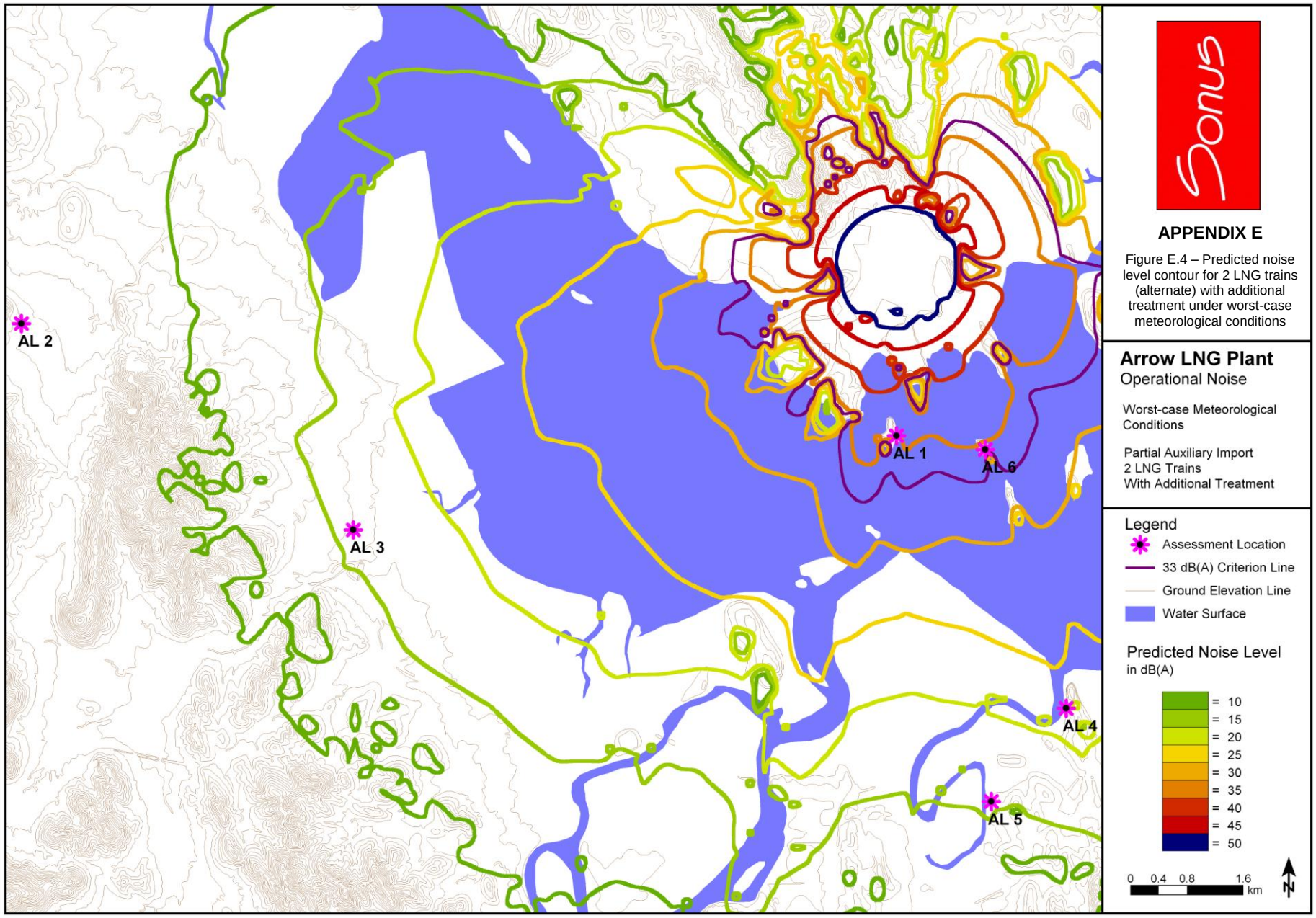

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX D
Figure D.8 – Predicted noise level contour for 4 LNG trains (alternate) under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Partial Auxiliary Import
4 LNG Trains
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

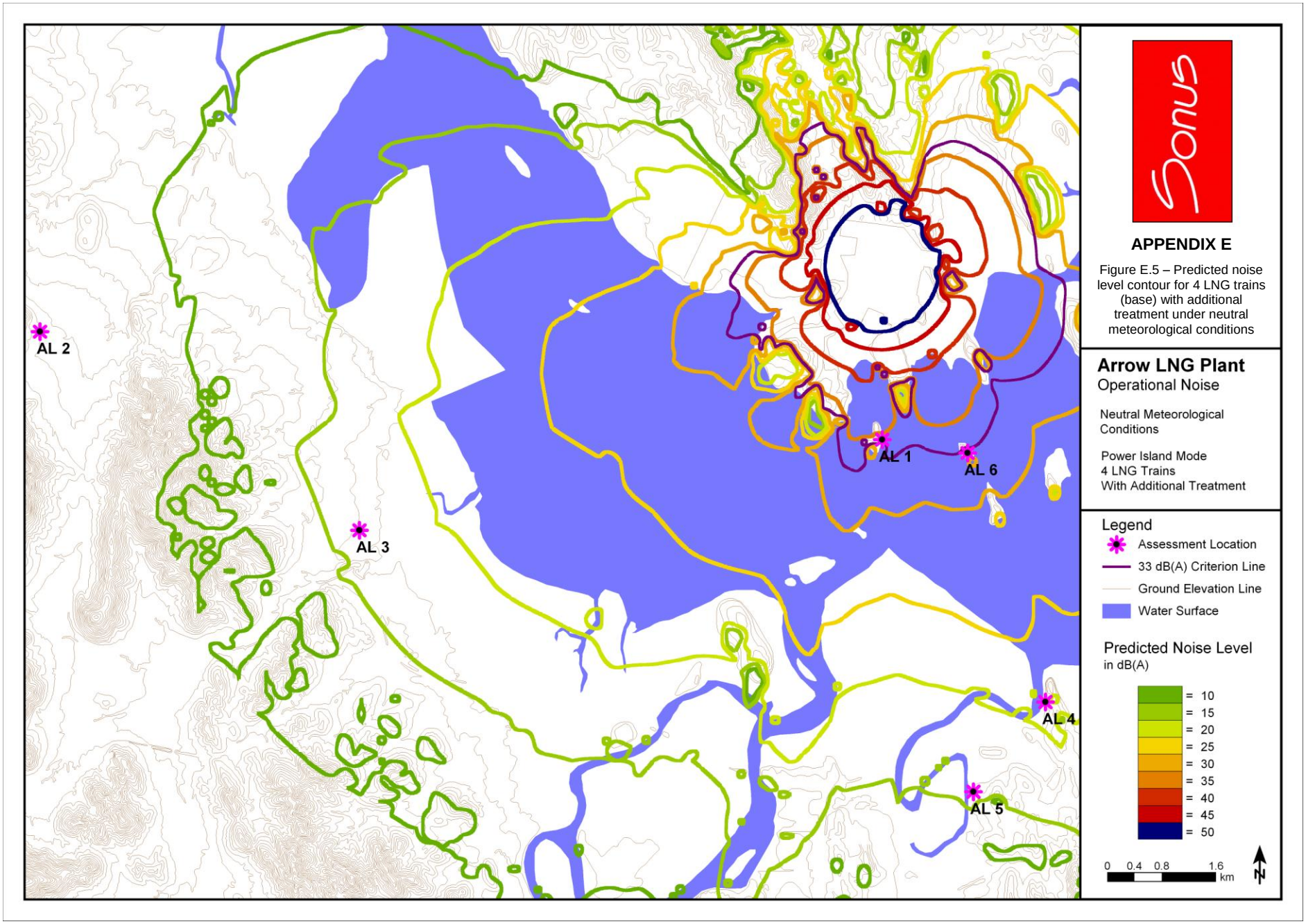
APPENDIX E: NOISE CONTOURS – WITH ADDITIONAL ACOUSTIC TREATMENT

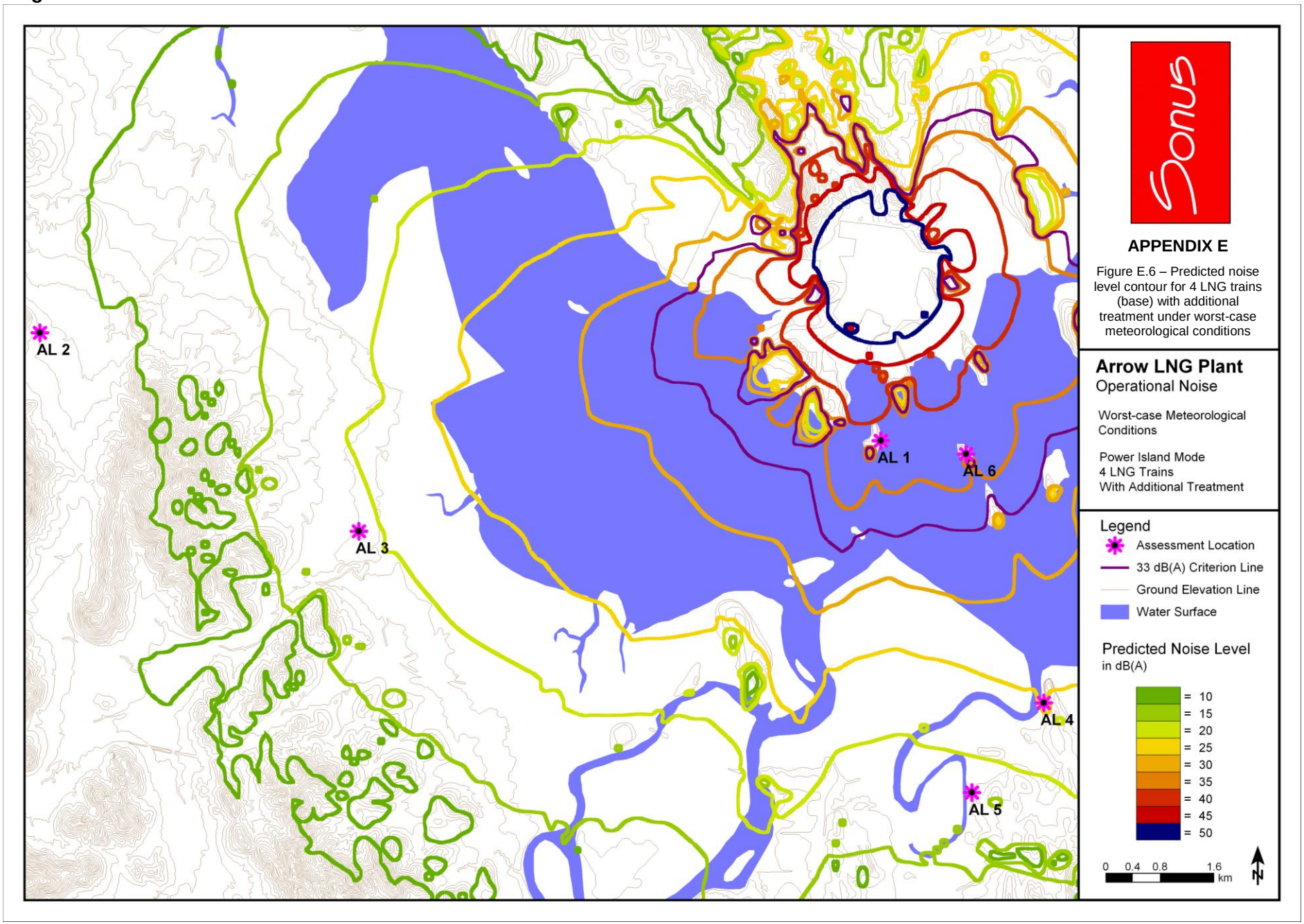

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
APPENDIX E
Figure E.1 – Predicted noise level contour for 2 LNG trains (base) with additional treatment under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Power Island Mode
2 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

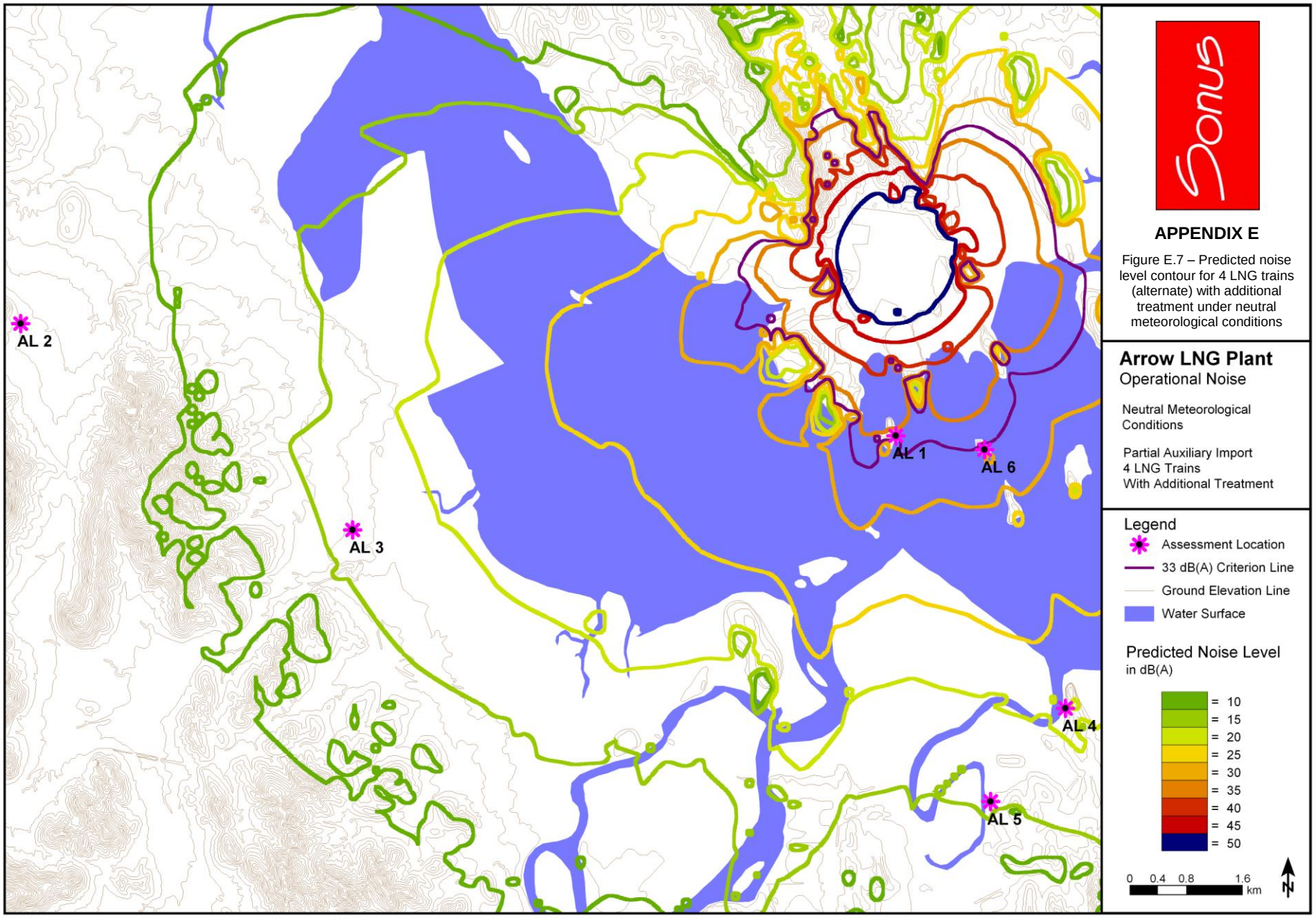

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.2 – Predicted noise level contour for 2 LNG trains (base) with additional treatment under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Power Island Mode
2 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N

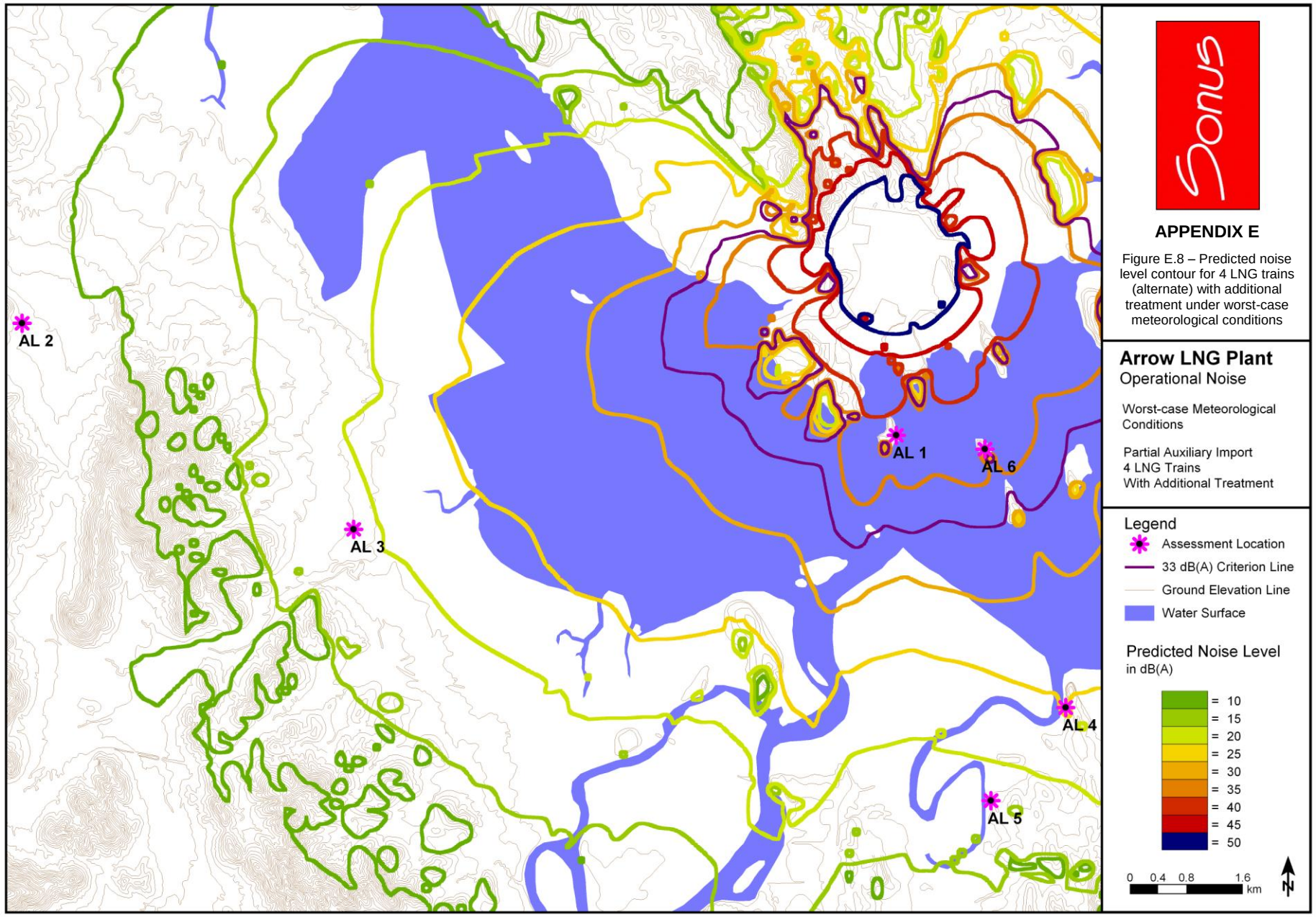

AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.3 – Predicted noise level contour for 2 LNG trains (alternate) with additional treatment under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Partial Auxiliary Import
2 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.4 – Predicted noise level contour for 2 LNG trains (alternate) with additional treatment under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Partial Auxiliary Import
2 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.5 – Predicted noise level contour for 4 LNG trains (base) with additional treatment under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Power Island Mode
4 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.6 – Predicted noise level contour for 4 LNG trains (base) with additional treatment under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Power Island Mode
4 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
Sonus
APPENDIX E
Figure E.7 – Predicted noise level contour for 4 LNG trains (alternate) with additional treatment under neutral meteorological conditions
Arrow LNG Plant
Operational Noise
Neutral Meteorological Conditions
Partial Auxiliary Import
4 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N


AL 2
AL 3
AL 1
AL 6
AL 4
AL 5
APPENDIX E
Figure E.8 – Predicted noise level contour for 4 LNG trains (alternate) with additional treatment under worst-case meteorological conditions
Arrow LNG Plant
Operational Noise
Worst-case Meteorological Conditions
Partial Auxiliary Import
4 LNG Trains
With Additional Treatment
Legend
Assessment Location
33 dB(A) Criterion Line
Ground Elevation Line
Water Surface
Predicted Noise Level
in dB(A)
= 10
= 15
= 20
= 25
= 30
= 35
= 40
= 45
= 50
0 0.4 0.8 1.6
km
N