APPENDIX Q COLDFOOT COMPRESSOR STATION ENVIRONMENTAL SOUND LEVEL ASSESSMENT REPORT

Alaska LNG™

COLDFOOT COMPRESSOR STATION ENVIRONMENTAL SOUND LEVEL ASSESSMENT REPORT

USAI-P2-SRVIB-00-000002-000

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1.0 INTRODUCTION

This report presents the results of an environmental sound level assessment for the proposed Coldfoot Natural Gas Pipeline Compressor Station (Station) as a part of the Alaska LNG Project (Project). Figure 1 of Appendix 1 shows the equipment layout for the Station. The Station equipment included in the assessment consisted of the following:

- One natural gas compressor unit consisting of a gas turbine driver (nominal 325 MMBTU/hr heat input @ HHV, International Organization for Standardization {ISO} rating of 41,675 hp) attached to a centrifugal natural gas compressor.
- Twenty four air-cooled heat exchangers (ACHEs) used to cool the compressed gas prior to proceeding down the pipeline.
- Two operating (and one stand-by) SI RICE power generators (nominal 15 MMBTU/hr heat input @ HHV, ISO rating of 1,680 hp each).
- Aboveground natural gas piping for the compressor inlet, recirculation, and outlet.

The purpose of this study was to provide an environmental sound level assessment for the Station, which includes the following tasks:

1. Develop a model to estimate the sound level contribution level from the facility at the nearest existing Noise Sensitive Areas (NSAs) in the vicinity of the Station.
2. Assess the far-field community sound levels at the identified NSAs for Station construction and normal full load operation.
3. Identify noise mitigation measures that could be implemented to comply with the Project environmental sound level criterion.

The Station is located between milepost (MP) 240 and MP 241. One nearby residential location has been identified as the nearest existing NSA as shown in Table 1. This NSA location is also representative of additional existing NSAs in the same general area but slightly farther from the Station as shown in Figure 2 of Appendix 1.

Table 1: List of Nearest Existing NSA Areas

Location Designation (Per GIS NSA Layer	Distance to Center of Facility
NSA_00410	5,774 feet S-SW

The acoustical modeling for the Project was conducted with a commercial noise modeling software, SoundPLAN (V7.4). Equipment sound power levels are based on published information and data of similar capacity/type equipment to those proposed for use by Alaska LNG.

As part of this study, a construction noise impact assessment for the worst-case scenario was also conducted.

2.0 ENVIRONMENTAL SOUND CRITERIA

The regulations in 18 Code of Federal Regulations (C.F.R.) § 157.206 set the maximum A-weighted day-night equivalent sound level, L_{dn}, of 55 decibels (dBA), which applies to the nearby NSAs. NSAs include residences, schools, hospitals, churches, playgrounds, and camping facilities. In accordance with the Federal Energy Regulatory Commission (FERC) criterion, the following formula is used to calculate the L_{dn}:

$$L_{dn} = 10\log_{10}\left[\frac{15\times10^{Leq(day)/10}+9\times10^{(Leq(night)+10)/10}}{24}\right]$$

where $L_{eq(day)}$ is the continuous equivalent daytime level over the daytime period, 7:00 am to 10:00 pm, and the $L_{eq(night)}$ is the continuous equivalent nighttime level over the nighttime period, 10:00 pm to 7:00 am. This calculation penalizes noise during the nighttime period by 10 dB. Thus, for continuous noise emissions, the maximum permissible equivalent continuous noise level at nearby NSAs is 48.6 dBA throughout the daytime and nighttime periods.

The FERC noise limit of Ldn 55 dBA is applicable to the normal full load operation of the Station. The FERC noise limit does not apply to the intermittent short-duration, process-related upset scenarios such as start-up, shutdown, discharge of safety relief valves, flaring scenarios, the operation of emergency electrical generators, or Station construction. Noise during these scenarios may exceed the FERC stipulated limits.

No applicable local or state environmental sound regulations or ordinances have been identified.

3.0 NOISE MODELING METHODOLOGY

The procedure for estimating the total (or overall) sound pressure level at any given location is as follows:

1. The octave band sound levels for a specific in-plant source or equipment item at a specific receiver location is calculated using the octave band sound power emission levels of a sound source and applying the octave band environmental correction factors as determined by the environmental conditions (e.g., atmospheric, topographical, foliage) between that source and the receiver.
2. This calculation is repeated for each source resulting in multiple octave band sound pressure level spectra at the receiver location.
3. The individual octave band sound pressure spectra for each source are then summed logarithmically on an energy basis (within each octave band) resulting in a total octave band sound pressure level spectrum accounting for the influence of all of the sound sources at the receiver location.
4. The total sound pressure level spectrum is then A-weighted and the resulting A-weighted octave band sound levels are summed on an energy or logarithmic basis to obtain the final overall A-weighted sound level that can be compared to the Project criteria.

Items 1–4 are repeated for each individual receiver location. Therefore, due to the complexity of determining the sound level at multiple receiver locations from multiple sound sources, it is advantageous to utilize a computer program incorporating standard algorithms that determine the sound level from each individual source, based on the environmental factors that separate the source from a receiver, and then combine the resulting individual sound levels from many sources into a total or cumulative sound level at that receiver.

The computer program utilized for this environmental noise level assessment is SoundPLAN Version 7.4 as distributed by Braunstein + Berndt GmbH. The program calculates the sound pressure level at a location utilizing the sound emission properties of the source(s) and environmental propagation factors (sound spreading due to distance, ground affects, barriers, topography, as well as atmospheric attenuation). The program also includes a number of standardized methodologies that can be utilized to quantify the acoustic effect of these environmental factors. The specific standard employed by this program is that described in the ISO standard 9613 “Acoustics – Attenuation of sound during propagation outdoors,” Parts 1 and 2. These standards assume a favorable downwind propagation condition (wind speed 1 meter/second to 5 meters/second at a height of 3 to 11 meters) as recommended in ISO standard 1996 “Acoustics – Description and measurement of environmental noise,” Part 2. The modeled ambient temperature was 2.5 degrees C and the assumed relative humidity was 70 percent. All receiver heights were 1.5 meters above the local ground level (AGL).

The topography was obtained from the Project GIS library and was used to create a topological digital ground model. The ground absorption value utilized in the model was 0.6, which is representative of grasslands. No sound attenuation due to foliage was included in the assessment.

4.0 CONSTRUCTION NOISE ASSESSMENT

The sound level due to construction is highly variable due the locations of the equipment on site and how it is being operated. Table 2 lists the construction equipment that would be utilized during the daytime construction activities (07:00 to 22:00 hours). This table includes each equipment item, the number that would be on site, the anticipated A-weighted sound pressure level at a distance of 50 feet, the utilization factor (UF) over the course of the daytime hours, and the reference for the sound level and UF. Table 3 lists the construction equipment that would be utilized during the nighttime construction activities (22:00 to 07:00 hours).

The equivalent overall A-weighted sound power level for each equipment item was computed with Equation 2.

$$\mathrm{PWLa} = \mathrm{SPLa50} + 20\,\mathrm{Log}(50) - 2.3 + 10\,\mathrm{Log}(UF) + 10\,\mathrm{Log}(\mathrm{No.}) \qquad \textbf{Eq. 2}$$

Where:

- PWLa is the computed equivalent overall A-weighted sound power level.
- SPLa50 is the A-weighted sound pressure level at a 50-foot distance.
- 20 Log (50) - 2.3 is the hemispherical spreading term for a 50-foot distance.
- UF is the Utilization Factor or percentage of time of equipment operation.
- No. is the number of equipment items on site.

The overall PWLa for each equipment item was converted to an octave band sound power level. This conversion is based on past experience with equipment of this type as well as published information from other environmental assessments. Due to the distance between the Station and the nearest NSA, the construction activity was modeled as two single-point sources (i.e., one for Daytime equipment and one for nighttime equipment) with a height of 2 meters AGL at a location within the limit of construction area. Given the relatively large distance from the site of the construction to the nearest NSAs, the use of two point sources is appropriate for this assessment. The daytime equipment was set to operate for the daytime hours only and the nighttime equipment was set to operate for the nighttime hours only.

Table 2: List of Daytime Construction Equipment

Equipment	Number on Site	Sound Pressure Level at 50 Feet (dBA)	Utilization Factor (UF)	Reference
Crane	3	85	16%	Federal Highway Administration (FHWA)
Dump Truck	3	84	40%	FHWA
Skip Loader	2	78	40%	FHWA (backhoe)
Bull Dozer	2	82	40%	FHWA
Excavator	2	85	40%	FHWA
Backhoe	3	78	40%	FHWA
Forklift	3	79	40%	FHWA (front end loader)
ATV	4	70	40%	Hoover & Keith (H&K) estimate
Compressor	4	78	50%	FHWA

Equipment	Number on Site	Sound Pressure Level at 50 Feet (dBA)	Utilization Factor (UF)	Reference
X-Ray	1	73	30%	H&K estimate
Welding Machine	4	74	50%	FHWA
Light Plant	4	70	20%	H&K estimate
Generator	4	81	100%	FHWA
Impact Pile Driver	2	101	30%	FHWA

Table 3: List of Nighttime Construction Equipment

Equipment	Number on Site	Sound Pressure Level at 50 feet (dBA)	Utilization Factor (UF)	Reference
Crane	1	85	8%	FHWA
Dump Truck	1	84	20%	FHWA
Skip Loader	1	78	20%	FHWA (backhoe)
Bull Dozer	1	82	20%	FHWA
Excavator	1	85	20%	FHWA
Backhoe	1	78	20%	FHWA
Forklift	2	79	30%	FHWA (front-end loader)
ATV	4	70	40%	H&K estimate
Compressor	2	78	40%	FHWA
X-Ray	1	73	30%	H&K estimate
Welding Machine	2	74	40%	FHWA
Light Plant	4	70	100%	H&K estimate
Generator	4	81	100%	FHWA
Impact Pile Driver	1	101	30%	FHWA

Table 4 shows the estimated A-weighted sound levels, due solely to the construction activities, at each of the 10 NSA evaluation points listed in Table 1 and shown on Figure 1.

Table 4: Estimated Sound Levels at the NSAs due to Construction

Designation	Ld (Daytime Level)	Ln (Nighttime Level)	Ldn (Day-Night Level)
NSA_00410	46.4	43.4	50.3

5.0 OPERATIONAL NOISE ASSESSMENT

This section presents the operational noise impact assessment for the Station. All of the equipment items utilized in the model were modelled as point sources. The specific items included for normal Station operation at full load were:

1. One gas turbine-driven centrifugal natural gas compressor unit installed within a pre-engineered metal building with a height of approximately 33 feet. The sound emission levels for the driver/compressor package are typical for the horsepower of this package and are representative of a skid-mounted unit without a skid-mounted enclosure. The building was assumed to be a 24-gauge metal building with a Sound Transmission Class (laboratory rating of 25 or greater. The interior surfaces of the building would be treated to obtain a Noise Reduction Coefficient (NRC) of 0.80 or greater. The natural gas compressor unit was treated as a "Hall-out" calculation within the mode; that is as a point source within a building with the software calculating the resulting sound emission levels through the building walls and roof.
2. One gas turbine air intake system (intake filter and ducting) for the gas turbine package, which is located adjacent to the compressor building and modeled as a point source with a height of 13 feet AGL.
3. One gas turbine exhaust system (ducting and in-line silencer) for the gas turbine package, which is located adjacent to the compressor building and is modeled as a point source with a height of 50 feet AGL.
4. One lube oil cooler for the natural gas compressor unit as is modeled as a point source with a height of 6 feet AGL. The lube oil cooler unit is a 100 dBA typical package.
5. Aboveground intake and exhaust piping servicing the natural gas compressor unit located with the Station site and modeled as a point source with a height of 4 feet AGL. The piping was assumed to have no exterior thermal or acoustical insulation.
6. Four air-cooled heat exchanger banks (ACHE). Each ACHE bank includes 12 individual axial fan/drive systems. Each ACHE bank was modeled as a point source with a height of 10 feet AGL. The sound power level (Lw) for each of the individual fan/drive systems was assumed to be equal to or less than 88 dBA.
7. Two electrical generators each driven by a reciprocating engine (1,680 hp). The generator units are installed near the gas compressor building and the engine exhausts are located outside adjacent to the generators with a source height of 10 feet AGL.

The equipment sound emission levels (L_w) for each of the sources included in the model is provided in Table 7 of Appendix 2. The data are representative of the full load sound emission levels with the equipment noise mitigation applied. The operation of the standby generators was not included in the sound level modeling for the full load Station operation.

The estimated sound levels at the nearest NSAs for the Station in normal full production are listed in Table 5 and are below the FERC criteria of Ldn 55 dBA.

Table 5: Sound Levels at the Nearest NSAs Due to Station Full Load Operation

Location Designation & Development Description	Distance to Center of Facility	Station at Full Normal Load (Ldn)
NSA_00410	5,525 feet S-SW	40.7

6.0 ESTIMATED SOUND LEVELS FOR NORMAL UNIT BLOWDOWNS

The sound levels associated with high-pressure gas venting are a function of initial blowdown pressure, the diameter and type of blowdown valve, and the diameter and arrangement of the downstream vent piping. As expected, blowdown sound levels are loudest at the beginning of the blowdown event and they decrease as the blowdown pressure decreases. The recommended blowdown silencer should have sufficient noise mitigation to limit the maximum sound level to less than 65 dBA at 300 feet (as measured 5 feet above the ground). With this degree of sound mitigation, it would be expected that the maximum sound level at the nearest NSAs to be as shown on Table 6.

Table 6: Estimated Initial Sound Levels for "Normal" Blowdown Event

Normal Blowdown Sound Source	Closest NSA	Distance/Direction to Blowdown Silencer	Estimated Initial Sound Level for Blowdown (dBA)
Unit Blowdown	Houses (NSA_00410)	5,725 feet S-SW	45

7.0 CONCLUSION

The analysis as presented indicates that with the application of proven noise mitigation technology, the Station, during full load operation, would be able to comply with the FERC environmental sound level criterion of Ldn 55 dBA based on the current design and operational assumptions. Estimates for Ldn sound levels at closest NSA related to construction and blowdown 40.7 and 45 dBA respectively.

8.0 ACRONYMS AND TERMS

Term	Definition
ACHE	air cooled heat exchanger
AGL	above the local ground level.
C.F.R.	Code of Federal Regulations
dBA	decibel
DIL	dynamic insertion loss – acoustical attenuation at the actual operating conditions
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
H&K Hoover & Keith	H&K
Hp	horsepower
ISO	International Organization for Standardization
L_{eq}	The A-weighted equivalent continuous sound pressure level
L_{dn}	Day and night sound pressure level, in dB(A) with 10 dB penalty at the defined night time from 22:00 to 7:00.
L_d	average daytime (07:00 to 22:00 hours) equivalent sound pressure level
L_n	average nighttime (22:00 to 07:00 hours) equivalent sound pressure level
MP	milepost
NSA	Noise Sensitive Area
Project	Alaska LNG Project
PWL	sound power level
SPL	sound pressure level
UF	Utilization Factor

9.0 REFERENCES

Document Number	Document Title
18 CFR 157.206	FERC Regulations on Noise (Ldn 55 dB(A) at the nearest NSAs)
ISO 9613-1	Part 1 - Calculation of the Absorption of Sound by the Atmosphere
ISO 9613-2	Part 2 - Acoustics-attenuation of Sound During Propagation Outdoors
ISO 1996-2	Part 2 - Acquisition of data pertinent to land use
USAI-P1-SRVIB-00-000001-000	Baseline Noise Level Report – MGP May/August 2015 Field Survey
USAP-WP-LDZZZ-00-000001-000_2	Typical Single-Unit Compressor Station with Cooling Plot Plan
Construction Noise Handbook	U.S. Department of Transportation, Federal Highway Administration, Office of Natural and Human Environment. FHWA-HEP-06-015, Final Report, August 2006
Tamar Valley Power Station	Noise Assessment, V1.0, June 2007, Sinclair Knight Merz, Malvem VIC, Australia.

APPENDIX 1

Figure 1: Equipment Layout for the Coldfoot Compressor Station

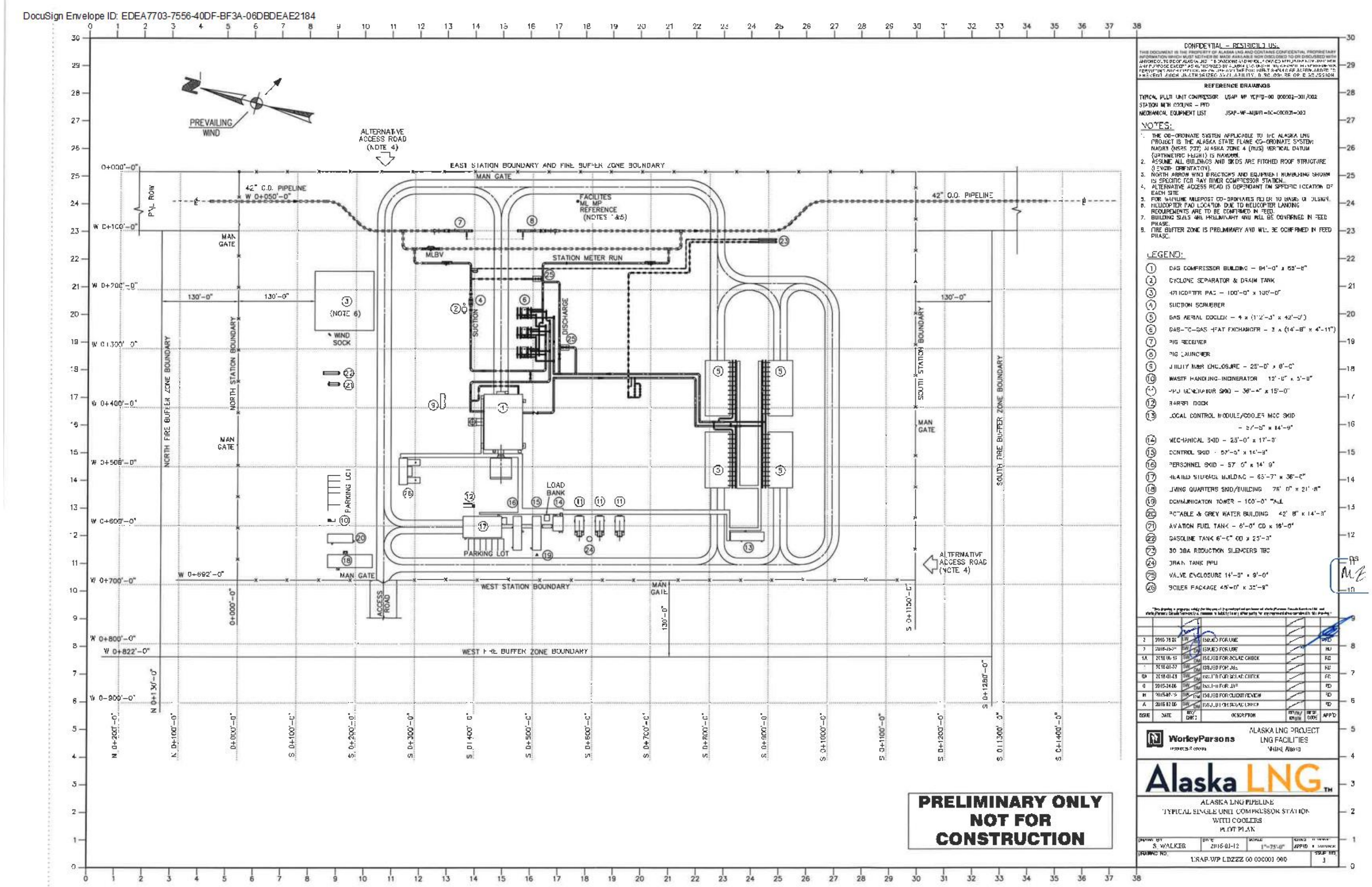
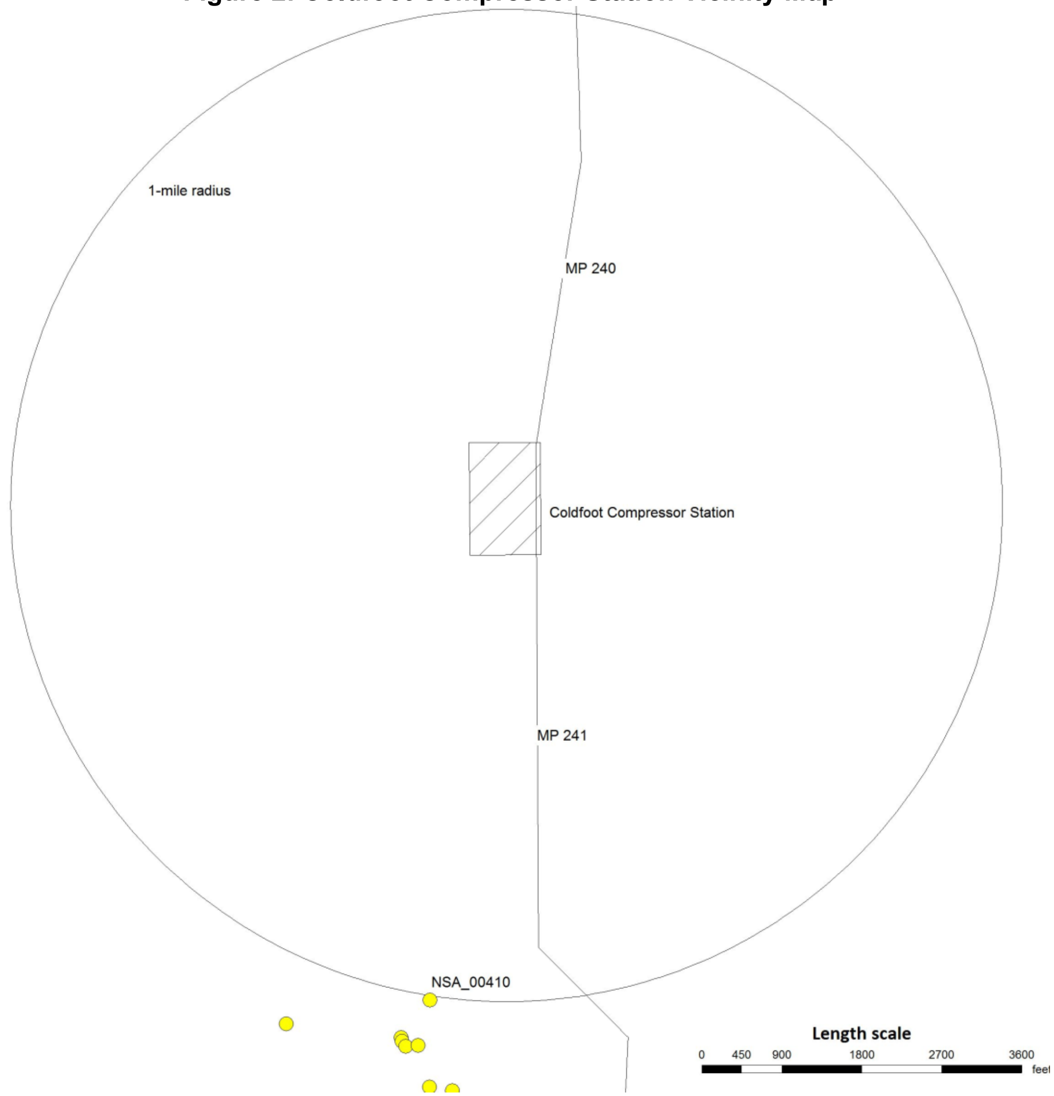


Figure 2: Coldfoot Compressor Station Vicinity Map



APPENDIX 2

Table 7: Equipment Sound Power Levels Used in SoundPLAN Model

Primary Equipment Description	Octave Band Center Frequency, Hz									Lw, dBA	Comments
	31.5	63	125	250	500	1000	2000	4000	8000		
Gas Turbine Exhaust	-	125	111	93	86	83	79	82	100	103	Exhaust duct
Gas Turbine Intake	-	129	121	113	106	99	99	98	98	111	Intake duct, filter house, and ventilation
GT Lube Oil Cooler	105	112	109	102	97	94	90	86	81	101	Standard 100 dBA
Aboveground Gas Piping	85	90	90	90	90	100	100	100	90	106	No Acoustical Insulation
Gas Cooler ACHE Units (Type of 4 Units in Operation)	118	121	120	115	109	107	102	101	96	113	24 bays of 2 fans per bay
Unenclosed Centrifugal Compressor Package	-	128	122	115	108	104	105	103	104	114	Inside Compressor Building
Power Generator	83	106	106	100	99	98	99	98	90	105	1,680 HP
Power Generator Exhaust	103	111	113	112	108	106	99	92	74	110	1,680 HP

Table 8: Daytime Construction Equipment Sound Power Levels Used in SoundPLAN Model

Equipment Description	Octave Band Center Frequency, Hz									Lw, (dBA)	Comments
	31.5	63	125	250	500	1000	2000	4000	8000		
Crane	111	115	114	111	113	106	104	103	96	113	3 Units w/ 16% UF
Dump Truck	114	118	117	114	116	109	107	106	99	116	3 Units w/ 40% UF
Skip Loader	101	106	113	106	106	103	102	92	86	109	2 Units w/ 40% UF
Bull Dozer	110	114	113	110	112	105	103	102	95	112	2 Units w/ 40% UF
Excavator	113	117	116	113	115	108	106	105	98	115	2 Units w/ 40% UF
Backhoe	103	108	115	108	108	105	104	94	88	110	3 Units w/ 40% UF
Forklift	109	113	112	109	111	104	102	101	94	111	3 Units w/ 40% UF
ATV	100	104	103	100	102	95	93	92	85	102	4 Units w/ 40% UF
Compressor	111	115	114	110	112	105	103	102	96	113	4 Units w/ 50% UF
X-Ray Station	96	100	99	96	100	92	90	88	81	99	1 Unit w/ 30% UF
Welding Machine	104	108	107	104	109	100	98	96	89	108	4 Units w/ 50% UF
Light Plant	97	101	100	97	99	92	90	89	82	99	4 Units w/ 20% UF
Generator	116	120	119	116	118	111	109	108	101	118	4 Units w/ 100% UF
Impact Pile Driver	98	108	123	113	130	123	125	120	113	131	2 Units w/ 30% UF
Total Daytime PWL	**121**	**125**	**127**	**122**	**131**	**124**	**125**	**121**	**114**	**132**	**All Daytime Equipment with the associated UFs**

Table 9: Nighttime Construction Equipment Sound Power Levels Used in SoundPLAN Model

Equipment Description	Octave Band Center Frequency, Hz									Lw, (dBA)	Comments
	31.5	63	125	250	500	1000	2000	4000	8000		
Crane	103	107	106	103	105	98	96	95	88	105	1 Unit w/ 8% UF
Dump Truck	106	110	109	106	108	101	99	98	91	108	1 Unit w/ 20% UF
Skip Loader	95	100	107	100	100	97	96	86	80	103	1 Unit w/ 20% UF
Bull Dozer	104	108	107	104	106	99	97	96	89	106	1 Unit w/ 20% UF
Excavator	107	111	110	107	109	102	100	99	92	109	1 Unit w/ 20% UF
Backhoe	95	100	107	100	100	97	96	86	80	103	1 Unit w/ 20% UF
Forklift	106	110	109	106	108	101	99	98	91	108	2 Units w/ 30% UF
ATV	100	104	103	100	102	95	93	92	85	102	4 Units w/ 40% UF
Compressor	107	111	110	106	108	101	99	98	92	109	2 Units w/ 40% UF
X-Ray Station	96	100	99	96	100	92	90	88	81	99	1 Unit w/ 30% UF
Welding Machine	100	104	103	100	105	96	94	92	85	104	2 Units w/ 40% UF
Light Plant	104	108	107	104	106	99	97	96	89	106	4 Units w/ 100% UF
Generator	116	120	119	116	118	111	109	108	101	118	4 Units w/ 100% UF
Impact Pile Driver	95	105	120	110	127	120	122	117	110	128	1 Units w/ 30% UF
Total Daytime PWL	**118**	**122**	**124**	**119**	**128**	**121**	**122**	**118**	**111**	**129**	**All Nighttime Equipment with the associated UFs**