Appendix 3 - Noise report

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Title: Langdale Rigg End – Potash / Polyhalite Drilling
Noise Assessment

Client: York Potash Limited

13 October 2011

QUALITY MANAGEMENT

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1 Introduction

1.1 SUMMARY

1.1.1 WSP Acoustics has been appointed to undertake an environmental noise assessment of proposed temporary drilling work at a site known as Langdale Rigg End. The site is located within Langdale Forrest, approximately 12km north-west of Scarborough in North Yorkshire.

1.1.2 The drilling work is proposed to determine the presence of underground Potash and Polyhalite. Whilst the proposed drilling site is in a fairly remote location and drilling works would be temporary in nature (an approximate 6 week drilling period is anticipated), it is proposed that the works would be undertaken 24 hours a day 7 days a week. The purpose of this assessment is therefore to determine the noise levels that are likely to be generated by such works at the closest local noise sensitive receptors (e.g. dwellings) and whether the resulting levels would be acceptable.

1.1.3 Following consultation with the Environmental Health Department of Scarborough Borough Council (SBC), this assessment has been undertaken to determine likely compliance with appropriate $L_{Aeq,T}$ (see Appendix A) noise level limits adopted from Minerals Policy Statement 2: *Controlling and Mitigating the Environmental Effects of Mineral Extraction in England - Annex 2: Noise.* The adopted noise level limits are also concordant with a stringent interpretation of the guidance contained with British Standard 5228: 2009: *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.* The guidance contained within the 1999 World Health Organisation publication: *Guidelines for community noise* and British Standard 8233: *Sound insulation and noise reduction for buildings - Code of practice* has also been referenced with respect to the L_{Amax} noise index (See appendix A).

1.1.4 Drawing upon the results of source noise emission data for two of the drilling rigs which are options for use at this site, a series of noise level predictions have been undertaken. These predictions have been undertaken in accordance with the methodology prescribed in International Standard Organisation (ISO) 9613*: Attenuation of sound during propagation outdoors - Part 2: General method of calculation.* It should be noted that this assessment method assumes downwind propagation and can therefore be considered to be worst case in this regard.

1.1.5 Where any exceedances of the applicable assessment criteria are identified, consideration has been given to appropriate noise mitigation measures.

1.1.6 This report is necessarily technical in nature, so to assist the reader, a glossary of acoustic terminology is presented in Appendix A.

2 Site Description

2.1 LOCATION

2.1.1 The site is known as Langdale Rigg End, and is shown in Figure B1 of Appendix B. The site is located in a fairly remote location within Langdale Forrest, approximately 7km east of the A190 (which connects Lockton and Briggswath), and approximately 2km north-west of Broxa Forrest.

2.2 LOCAL NOISE-SENSITIVE RECEPTORS

2.2.1 The closest noise sensitive receptor to the site has been identified by means of a desk review and a site walkover. The desk review included an appraisal of Ordnance Survey mapping for the site and surrounding area, and a review of available on-line aerial photography. It has been identified that the closest noise-sensitive receptor to the proposed drilling site is as follows:

- Receptor 1: High Langdale End, a residential property approximately 610m to the east of the site.

2.2.2 The above receptor is also identified in Figure B1 of Appendix B.

2.2.3 The next closest receptors to the site are at distances of greater that 2km.

2.3 LOCAL NOISE ENVIRONMENT

2.3.1 During the site visit, the local noise environment was observed to be dominated by natural sources such as water courses, rustling / movement of vegetation and bird song etc.

3 Legislation, Guidance and Consultation

3.1 MINERALS POLICY STATEMENT 2: CONTROLLING AND MITIGATING THE ENVIRONMENTAL EFFECTS OF MINERAL EXTRACTION IN ENGLAND - ANNEX 2: NOISE

3.1.1 As the proposed drilling works are associated with potential mineral extraction, this document constitutes the key guidance for this assessment.

3.1.2 This document states that it is "*a statement of the policy considerations in relation to mineral workings and associated operations, and how they should be dealt with in local development frameworks and in consideration to individual applications.*"

3.1.3 Paragraph 2.19 of this document describes a series of noise level limits applicable to mineral sites during different times of the day, evening and night-time. It is stated that the specified noise level limits will normally be set at the noise-sensitive properties, as this enables the effect of noise to be related most directly to its impact on local people, but that in some instances it may be more appropriate to set the limits at the site boundary or other point. For the purpose of this assessment, the noise level limits used relate to the closest noise-sensitive receptors.

3.1.4 It is stated that the noise level limit should not exceed a maximum of 55dB(A) $L_{Aeq,1hour}$ (free-field) and that the Mineral Planning Authority (MPA) should aim to establish a noise level limit that does not exceed the background noise level by more than 10dB(A), but the point is made that in many circumstances, this will be difficult to achieve without placing unreasonable burden's on the mineral operator. Accordingly, the following free-field limits are also specified:

- During normal working hours (07:00 to 19:00): Emission levels should be as near as possible to 10dB(A) above the background level, but not exceeding 55dB $L_{Aeq,1hour}$;
- Evening (19:00 to 22:00): Emission levels should not exceed the background noise level by more than 10dB(A); and
- Night-time (time period not stated but assumed to be the remaining hours of 22:00 to 07:00): Emission levels should not exceed 42dB(A) $L_{Aeq,1hour}$.

3.1.5 These noise limits apply to a free-field condition external to the property/receptor.

3.1.6 In addition to the limits specified above, which are for '*normal*' operations, this document also identifies that some short-term activities may generate higher noise levels, but which also have longer term environmental benefits. Stated examples include soil stripping, the construction and removal of baffle mounds, soil storage mounds and spoil heaps. For such activities, higher noise levels limits, of up to 70dB(A) $L_{Aeq,1hour}$ (free-field) are proposed for periods of up to 8 weeks a year.

3.1.7 Given that night-time workings are proposed, this assessment has adopted the night-time noise level limit of 42dB(A) $L_{Aeq,T}$ as this is considered to be the limiting scenario. This noise level limit is also concordant with sample assessment criteria contained within BS5228, as summarised below.

3.1.8 With regards to 'peak' or 'impulsive' noise, MPS 2, states that such noises may require separate noise level limits, but no specific guidance criteria is provided. Accordingly, consideration has been given to the guidance presented in BS8233, and that provided by the World Health Organisation, as summarised below.

3.2 BS5228: 2009: CODE OF PRACTICE FOR NOISE AND VIBRATION CONTROL ON CONSTRUCTION AND OPEN SITES – PART 1: NOISE

3.2.1 This Standard sets out techniques to predict and assess the likely noise effects from construction works, based on detailed information on the type and number of plant being used, their location, and the length of time they are in operation. This Standard includes example criteria for the assessment of the significance of noise effects. Such criteria are concerned with fixed noise limits and ambient noise level changes.

3.2.2 With respect to fixed noise limits, BS5228 discusses those included within Advisory Leaflet 72: 1976: *Noise Control on Building Sites*. These limits are presented according to the nature of the surrounding environment. For a 12-hour working day, the following noise levels limits are presented:

- 70.0 dB(A) in rural, suburban and urban areas away from main road traffic and industrial noise; and
- 75.0 dB(A) in urban areas near main roads and heavy industrial areas.

3.2.3 When working outside normal working hours (e.g. 19:00 to 22:00), it is suggested that the above limits could be reduced by 10dB (i.e. to 60 and 65 dB(A) respectively). No specific limit is suggested for the night-time (22:00 to 07:00), but it is stated that work likely to cause annoyance locally should not be permitted. It can therefore be seen that higher limits apply during the daytime and evening compared to the night-time.

3.2.4 The standard goes on to provide methods for determining the significance of construction noise levels considering the change in the ambient noise level as a result of the construction operations. Two example assessment methods are presented, these are the ABC method and the 5 dB(A) change method. Both of these methods are subject to an absolute lower level criteria during the night-time period, regardless of the prevailing background noise levels.

3.2.5 The ABC method compares the total noise level (including construction noise) against a series of criteria for daytime, evening and night periods. Three categories of criteria are provided (A, B and C), each with separate limits for the daytime, evening and night-time. For each category, the daytime limit is 10dB higher than the evening limit which is in turn 10dB higher than the night-time limit. The category which is to be adopted (A, B or C) depends on the prevailing level without construction. However, assuming that the night-time level without construction is less than 42 dB $L_{Aeq,T,}$ then the most stringent of the Categories (A) will always apply, and the allowable construction noise level (alone) will also always be at least 42 dB $L_{Aeq,T}$.

3.2.6 For the 5dB change method, construction noise levels are deemed to be significant if the total noise level (with construction) exceeds the level without construction by 5dB or more, subject to a lower cut-off values of 65, 55, and 45 dB $L_{Aeq,T}$ (construction only) for the daytime, evening and night-time periods. It can therefore be seen that again, the most stringent criteria applies during the night-time and that in this case, the allowable construction noise level during the night-time period will always be at least 45 dB $L_{Aeq,T}$.

3.2.7 Accordingly, adoption of a 42 dB $L_{Aeq,T}$ criterion for the night-time period can be seen to be in accordance with MPS2, and concordant with a worst case interpretation of BS5228. It can also be concluded that higher noise level limits should apply during both the daytime and evening periods compared to the night-time, and therefore that the night-time period is that which poses the greatest constraint.

3.3 BS 8233: 1999: SOUND INSULATION AND NOISE REDUCTION FOR BUILDINGS - CODE OF PRACTICE

3.3.1 This standard provides recommendations for the control of noise in and around buildings. It suggests appropriate criteria and limits for different situations, which are primarily intended to guide the design of new buildings, or refurbished buildings undergoing a change of use, rather than to assess the effect of changes in the external noise climate.

3.3.2 The standard suggests suitable internal noise levels within different types of buildings, including residential dwellings. This document includes guidance on the acceptability of noise levels generated by individual events during the night-time, in terms of the L_{Amax} noise index, stating that "*individual noise events should not normally exceed 45 dB L_{AFmax} in bedrooms at night*".

3.3.3 This criteria applies internally. Assuming a 12dB loss through an open window[1], the equivalent external criterion is 57 dB L_{AFmax}, free-field.

3.4 WORLD HEALTH ORGANISATION (WHO): 1999: GUIDELINES FOR COMMUNITY NOISE

3.4.1 This is a wide ranging document describing the effects of community noise. It provides information about the effects of noise that may occur at certain levels of exposure. For dwellings, the critical effects of noise are taken to be sleep disturbance, annoyance and speech interference.

3.4.2 This document also includes guidance on the acceptability of maximum noise levels within dwellings and makes reference to the findings from research conducted by Vallet & Vernet, 1991. This research states:

[1] BS8233 states that with windows open to provide rapid ventilation and summer cooling, the noise reduction through a window opening will reduce to about 10 or 15dB. The same range is also stated within Planning Policy Guidance Note 24: *Planning and noise*.

"For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{AFmax} more than 10-15 times per night"

3.4.3 Again, this criterion applies internally. Assuming a 12dB loss through an open window[1], the equivalent external criterion is 57 dB L_{AFmax} not more than 10 to 15 times per night.

3.5 ASSESSMENT CRITERIA

3.5.1 Drawing upon the above guidance documents, the following assessment criteria have been adopted for the night-time period:

- An external noise emission level of 42dB $L_{Aeq,T}$ free-field; and
- An external noise emission level of 57dB L_{Amax}, free-field.

3.6 ISO 9613: ACOUSTICS - ATTENUATION OF SOUND DURING PROPAGATION OUTDOORS, PART 2: GENERAL METHOD OF CALCULATION

3.6.1 This document presents a standardised method for the determination of environmental noise levels at distance from sources with known emission levels. The standard is stated to be applicable to a variety of different sources under favourable meteorological conditions for propagation (i.e. downwind). The prescribed method consists specifically of octave band algorithms (for the octaves centred on 63Hz to 8kHz), for calculating the attenuation of sound from a point source. The algorithms are used to determine the attenuation from a number of effects including:

- geometrical divergence (i.e. distance);
- atmospheric absorption;
- ground effect;
- reflection(s) from surfaces; and
- screening by obstacles.

3.7 CONSULTATION

3.7.1 At the outset of the project, consultation was undertaken with the Environmental Health Department of Scarborough Borough Council (SBC), and the above assessment criteria were agreed in principle. The approach to the prediction of drilling noise levels was also agreed, including use of the ISO 9613 prediction methodology, with source data adopted from the results of environmental noise measurements previously undertaken for two of the drilling rigs (as summarised below) which are options for use at the site.

4 Source Data

4.1 SUMMARY

4.1.1 Environmental noise measurement reports have been provided for two of the proposed drilling rigs which are options for use at this site. The pertinent data from these reports are presented below.

4.2 BRITISH DRILLING AND FREEZING (BDF) RIG 28

4.2.1 The environmental noise levels generated by BDF Rig 28 were determined in 2005 by Acoustic and Engineering Consultants (AEC) Ltd. The pertinent technical report presents the results of environmental noise measurements during drilling works at a depth of approximately 3500ft.

4.2.2 Noise measurements were undertaken under free-field conditions at eight different locations around the perimeter of the drilling site. Measurements were undertaken using Type 1 specification noise measurement equipment which was calibrated at the beginning and end of measurements. No significant drifts in calibration were noted.

4.2.3 Measurements were undertaken during the operation of all rig equipment, including an auxiliary generator and centrifuge. These two items are not standard equipment items for this rig, i.e. they are not permanently associated with Rig 28 and may not be present in all deployments. It is stated within the report that levels between 2 and 3dB lower than those measured are anticipated without the operation of these two plant items.

4.2.4 The completed noise measurements included octave band spectra. A summary of the measurement results are presented in Table 1 below.

TABLE 1 MEASURED SOUND PRESSURE LEVEL SPECTRA FOR BDF RIG 28, AND RESULTING SOUND POWER LEVELS, dB, LINEAR UNLESS STATED

Location Reference	Distance	Direction	Octave band Centre Frequency (Hz)								A-weighted Noise Level, dB(A)	Level Normalised to 1m, dB(A)	A-weighted Sound Power Level (L_{WA})
			63	125	250	500	1k	2k	4k	8k			
1	25	N	79	74	70	68	63	61	57	49	69.8	97.8	105.8
2	35	NW	81	79	76	71	67	63	57	47	73.4	104.3	112.3
3	35	NE	72	72	68	65	61	55	49	40	66.6	97.5	105.5
4	32	SE	70	69	68	68	63	54	45	36	68.1	98.2	106.2
5	20	S	75	72	78	72	68	61	54	46	74.0	100.0	108.0
6	32	SW	74	71	72	68	63	58	51	41	69.3	99.4	107.4
7	25	E	70	67	69	63	56	51	44	37	64.5	92.5	100.5
8	25	W	85	81	81	76	74	70	62	53	79.1	107.1	115.1
Energy Averaged Sound Power Level, dB(A)													**109.6**

4.2.5 It can be seen from Table 1 above that the measured noise emission level depends upon the measurement location (and therefore the orientation of the equipment) as well as the measurement distance. At this stage, the orientation of the equipment within the drilling site is flexible, therefore, it is appropriate to adopt the energy averaged level which tends towards the higher measured noise levels.

4.2.6 Drawing upon the table above, an energy averaged octave band spectra has been calculated and is presented in Table 2 below. The spectrum presented in Table 2 is in terms of Sound Power Level, and should therefore not be compared directly with the sound pressure level spectra presented in Table 1 above.

TABLE 2 ENERGY AVERAGED OCTAVE BAND SOUND POWER LEVEL SPECTRA FOR BDF RIG 28, L_{WA}, dB, LINEAR UNLESS STATED

Octave band Centre Frequency (Hz)								A-weighted Sound power Level (L_{WA})
63	125	250	500	1k	2k	4k	8k	
115.7	112.8	111.9	107.3	104.0	99.5	92.6	83.5	109.6

4.2.7 The results of short term attended measurements are also presented within the report at distance from the drilling site but during typical operations. The highest measured L_{Amax} noise level was identified to be 55dB(A) at 390m. This maximum noise level was measured during 'tripping out' operations. Lower maximum noise levels were measured during drilling operations.

4.3 FORACO BF831 POLYVALENT TRUCK-POWERED TOP DRIVE RIG

4.3.1 The environmental noise levels generated by the Foraco BS831 rig were determined in 2003 by Spectrum Acoustic Consultants. The pertinent technical report presents the results of environmental noise measurements during drilling works at Boreholes 1G and 2G at the Hole House Gas Storage Facility west of Warmington in Cheshire.

4.3.2 Noise measurements were undertaken in four different directions around the perimeter of the drilling site. Measurements were undertaken at both 50 and 100m in each direction selected and a total of eight measurement locations were therefore adopted. Measurements were undertaken using Type 1 specification noise measurement equipment and a portable acoustic calibrator. The equipment had been calibrated to traceable standards.

4.3.3 Measurement data were reported in terms of broad-band A-weighted values (i.e. not spectral data), and a summary of the results can be seen in Table 3 below.

TABLE 3 NOISE MEASUREMENTS AROUND FORACO BF831 RIG, WITH CALCULATED SOUND POWER LEVEL (L_W)

Measurement Direction	$L_{Aeq,1minute}$ dB(A)	
	50m	100m
A	69	64
B	70	-
C	69	62
D	67	62
Energy Average	69	63
Sound power Level	**110**	**111**

4.3.4 It is considered that the most accurate sound power level determination would be calculated based on the measurement data at 50m, as at this distance there is less potential for errors associated with factors such as ground absorption, air absorption and meteorological conditions etc.

4.3.5 Maximum noise levels were also measured at distances of 600m and 1100m from the drilling site, but it is evident form the report text that the measured levels at 1100m were primarily dominated by local sources, not the drilling operation, and it is anticipated that the measured maximum noise levels at 600m may also have been contaminated by sources other than the drilling operation.

4.3.6 Comparing Tables 2 and 3, it can be seen that very similar sound power levels are determined for the two sample rigs. Therefore, given that the BDF Rig includes spectral data, the noise emission data presented in Table 2 have been used in the determination of the noise levels that may be generated at receptors local to this site. To determine the resulting maximum noise levels the BDF measurement data of 55dB(A) L_{Amax} at 390m has been adopted.

5 Assessment

5.1 DETAILED NOISE MODEL

5.1.1 To facilitate the ISO9613 noise level predictions, a detailed noise model of the site and surrounding area has been prepared within the CadnaA® PC based noise modelling suite. The approach to the preparation of the detailed noise model is presented below.

- The noise model was set to apply the ISO 9613 *Acoustics – Attenuation of sound during propagation outdoors* noise prediction methodology. By default, this methodology predicts the noise level that would be generated downwind from the source in question (wind direction within an angle of +/- 45 degrees of the direction connecting the source and receiver, with wind blowing from the source).
- Ordnance Survey mapping of the site and surrounding area was calibrated into the noise model based on known Ordnance Survey grid reference points.
- Ordnance Survey 10m ground contour detail for the site and surrounding area was incorporated into the model to account for any topographic effects such as screening.
- To reflect the local ground cover, ground absorption was set to 1 (soft ground) as appropriate for a rural area.
- A point noise source representing the proposed drilling works was located at the centre of the proposed drilling site. Whilst the key sources which will dictate the $L_{Aeq,T}$ noise level will be at a height between 0 and 1m, a nominal source height of 1.5m was selected as a worst case.
- The octave band sound noise data presented in Table 2 was applied to the point noise source.
- No perimeter noise bunding was incorporated around the drilling site boundary, although in practice such bunding will be created when stripped top soil is stored on site.

5.1.2 The closest existing noise sensitive receptor to the drill site was incorporated as receiver with a height of 1.5m above ground.

5.1.3 The noise model was run twice, firstly to determine the resulting $L_{Aeq,T}$ noise level at the closest receptor point, and secondly to generate a noise map of the local area at a height of 1.5m above ground. The resulting noise map can be seen in Figure C1 of Appendix C, with the individual receptor noise level presented in Table 4 below.

5.1.4 Also presented in Table 4 is the calculated L_{Amax} noise level at the clsoest receptor. The L_{Amax} noise level has been calculated by applying a standard acoustic distance correction for a point source (a 6dB loss per doubling of distance) to the source data detailed in paragraph 4.3.6.

5.1.5 Table 4 also presents the adopted assessment criteria, and the amounts by which each of the criteria are predicted to be achieved or exceeded at the closest receptor location.

TABLE 4 ASSESSMENT OF PREDICTED DRILLING NOISE LEVELS FOR THE NIGHT-TIME PERIOD, FREE-FIELD, dB(A)

Receptor Reference	Receptor Description	Noise Index	Predicted Emission Noise Level [A]	Night-time Assessment Criterion [B]	[A] – [B]
1	High Langdale End	$L_{Aeq,T}$	29.9	42	Met by 12dB
		L_{Amax}	50.6	57	Met by 6dB

5.1.6 It can be seen from Table 4 above that the adopted night-time assessment criteria are predicted to be achieved the closest receptor to the proposed drilling site. As discussed in Paragraph 3.2.7, the night-time assessment criteria are the most stringent. Therefore, applicable daytime and evening criteria are also expected to be achieved.

6 Mitigation

6.1.1 As the adopted night-time assessment criteria are predicted to be achieved at the closest receptor to the proposed drilling site, specific consideration to noise mitigation measures is not warranted.

6.1.2 However, given that the adopted source data identified varying noise levels depending on the measurement location and equipment layout, it should be noted that the final noise levels will depend upon the site equipment orientation. Therefore, in order to minimise generated noise levels, care should be taken with the proposed plant layout. For example, noisy plant items should be screened where possible by the careful location of solid structures such as the site workshop, office, sleeper units, lockers, tanks etc.

6.1.3 Furthermore, additional noise attenuation can be afforded by the formation of earth bunds around the perimeter of the drilling site, for example where stripped soil has to be stored. To ensure the acoustic integrity of such bunds, they should be continuous and fully screen the line of sight between the receptors and the noise sources within the drilling site. MPS 2 states that reductions of between 5 and 10dB can be achieved by bunds close to the source, depending on whether the noise is partially or completely screened from the measurement point (e.g. the receptor).

7 Conclusion

7.1.1 WSP Acoustics has been appointed to undertake an environmental noise assessment of proposed temporary drilling work at a site known as Langdale Rigg End. The site is located within Langdale Forrest, approximately 12km north-west of Scarborough in North Yorkshire.

7.1.2 The drilling work is proposed to determine the presence of underground Potash and Polyhalite. Whilst the proposed drilling site is in a fairly remote location, and drilling works would be temporary in nature (an approximate 6 week drilling period is anticipated), it is proposed that the works would be undertaken 24 hours a day 7 days a week. Accordingly, this assessment has been undertaken to determine the noise levels that are likely to be generated by such works at the closest local noise sensitive receptor (e.g. dwelling), and whether the resulting levels would be acceptable during the daytime, evening and night-time.

7.1.3 The assessment has identified that the closest noise-sensitive receptor to the drilling site is High Langdale End, a residential dwelling located approximately 650m to the east.

7.1.4 In accordance with the result of consultation with the Environmental Health Department of Scarborough Borough Council (SBC), a series of noise level predictions have been undertaken in accordance with the methodology prescribed in International Standard Organisation (ISO) 9613*: Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*, to determine the noise levels that are likely to be generated at the closest identified receptor to the drilling site. The noise level predictions have been based on the results of noise emission data which have previously been determined for two drilling rigs, both of which are options for use at this site.

7.1.5 The results of the noise level predictions have been assessed based on noise level criteria applicable to the night-time period (a worst case, with less stringent criteria being applicable to evening and daytime periods).

7.1.6 The adopted noise level criteria have been selected in full accordance with Minerals Policy Statement 2: *Controlling and Mitigating the Environmental Effects of Mineral Extraction in England - Annex 2: Noise.* The adopted noise level limits are also concordant with a worst case interpretation of the guidance contained with British Standard 5228: 2009: *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise.* The guidance contained within the 1999 World Health Organisation publication: *Guidelines for community noise* and British Standard 8233: *Sound insulation and noise reduction for buildings - Code of practice* has also been referenced with respect to the L_{Amax} noise index.

7.1.7 In accordance with these documents, the night-time assessment criteria which have been adopted are emission levels of 42dB $L_{Aeq,T}$ and 57dB L_{Amax}, external, free-field (equivalent to 30dB $L_{Aeq,T}$ and 45dB L_{Amax} internal assuming partially open windows).

7.1.8 The results of the completed noise level predictions have identified that the adopted criteria will be met at the closest local receptor, and by margins of between 6 and 12dB. Accordingly, it can be concluded that the resulting noise levels will be acceptable during the night-time period, and also during the daytime and evening periods for which applicable criteria would be achieved by even greater margins.

7.1.9 As the applicable criteria are expected to be achieved, no further consideration to noise mitigation measures is considered warranted. Nonetheless, advice has been provided regarding good practice in the design and setup of the drilling rig, and also with regards to additional attenuation that could be afforded by the formation of earth bunds for soil storage around the drilling site.

7.1.10 In summary, the completed assessment has identified that the noise levels predicted to be generated by the proposed drilling works will be acceptable and will meet appropriate daytime, evening and night-time assessment criteria determined in accordance with a stringent interpretation of applicable national guidance, including Minerals Policy Statement 2: *Controlling and Mitigating the Environmental Effects of Mineral Extraction in England - Annex 2.* It is therefore concluded that noise need not be considered a determining factor in granting planning approval for 24 hour drilling works at this site.

WSP ACOUSTICS

Appendix A Glossary of Acoustic Terminology

NOISE

Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq}, L_{A90} etc, according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

TYPICAL SOUND LEVELS FOUND IN THE ENVIRONMENT

Sound Level	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 4 0dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of pain

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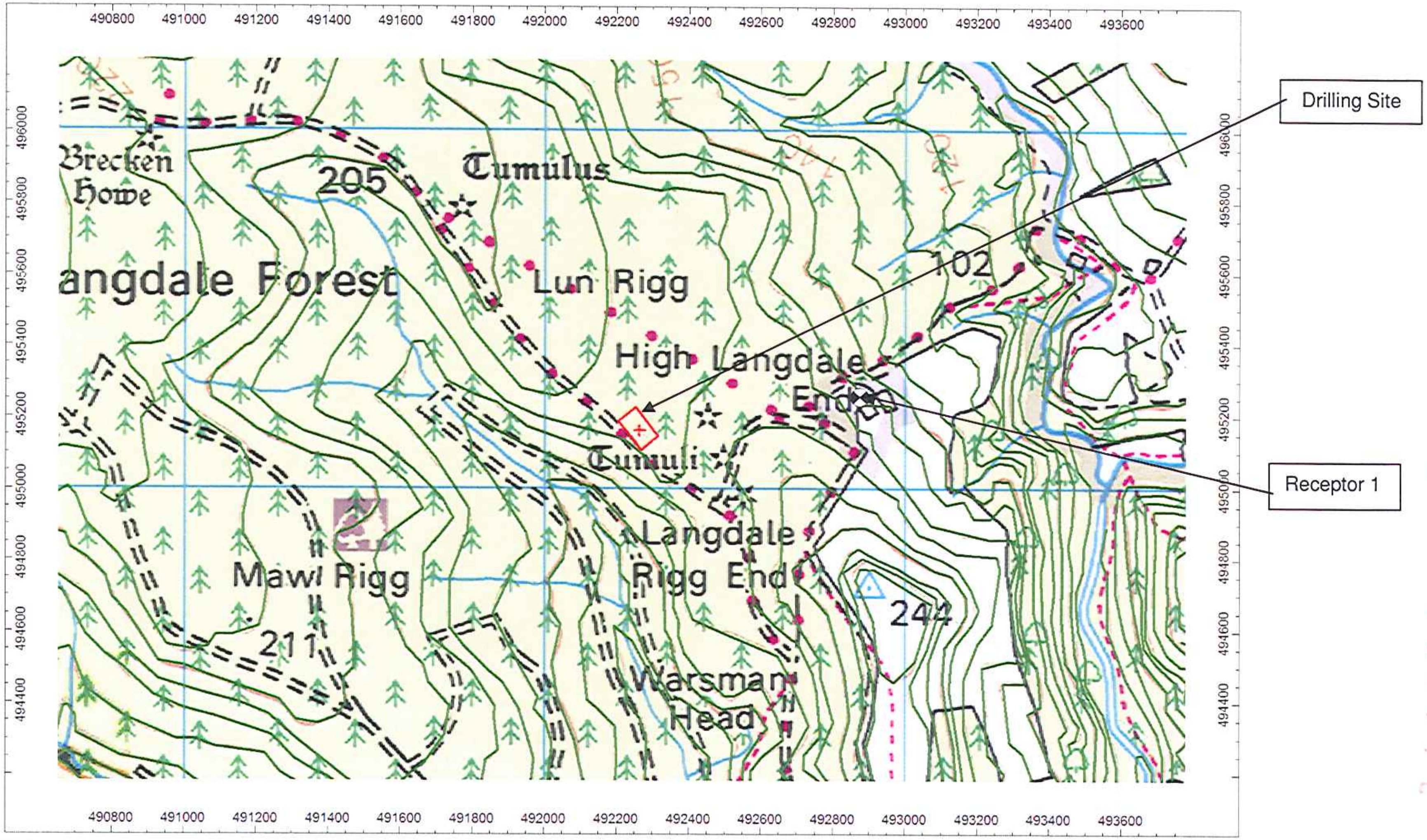
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$ Pa).
dB(A)	A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
$L_{Aeq\ T}$	L_{Aeq} is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.
L_{Amax}	L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{10} & L_{90}	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time. Hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the 'average minimum level' and is often used to describe the background noise. It is common practice to use the L_{10} index to describe traffic noise.
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other reflective surfaces. Generally as measured outside and away from buildings.
Façade Level	A sound field determined at a distance of 1m in front of a large sound reflecting object such as a building façade.
Sound Pressure Level	The sound pressure level at a point is measured in decibels (dB) and is equal to 20 times the logarithm to the base 10 of the ratio of R.M.S. sound pressure to the reference sound pressure. The reference sound pressure in air is taken to be $2x10^{-5}$ Pa.
Sound Power Level	Sound power is neither room dependent nor distance dependent. Sound power belongs strictly to the sound source. The sound power level SWL, L_W, or L_{Pac} of a source is expressed in decibels (dB) and is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to a reference sound power. It is thus a logarithmic measure. The reference sound power in air is normally taken to be 10^{-12} watt.
Background Noise Level	The noise level in the absence of the industrial source noise under consideration, measured in L_{A90}.

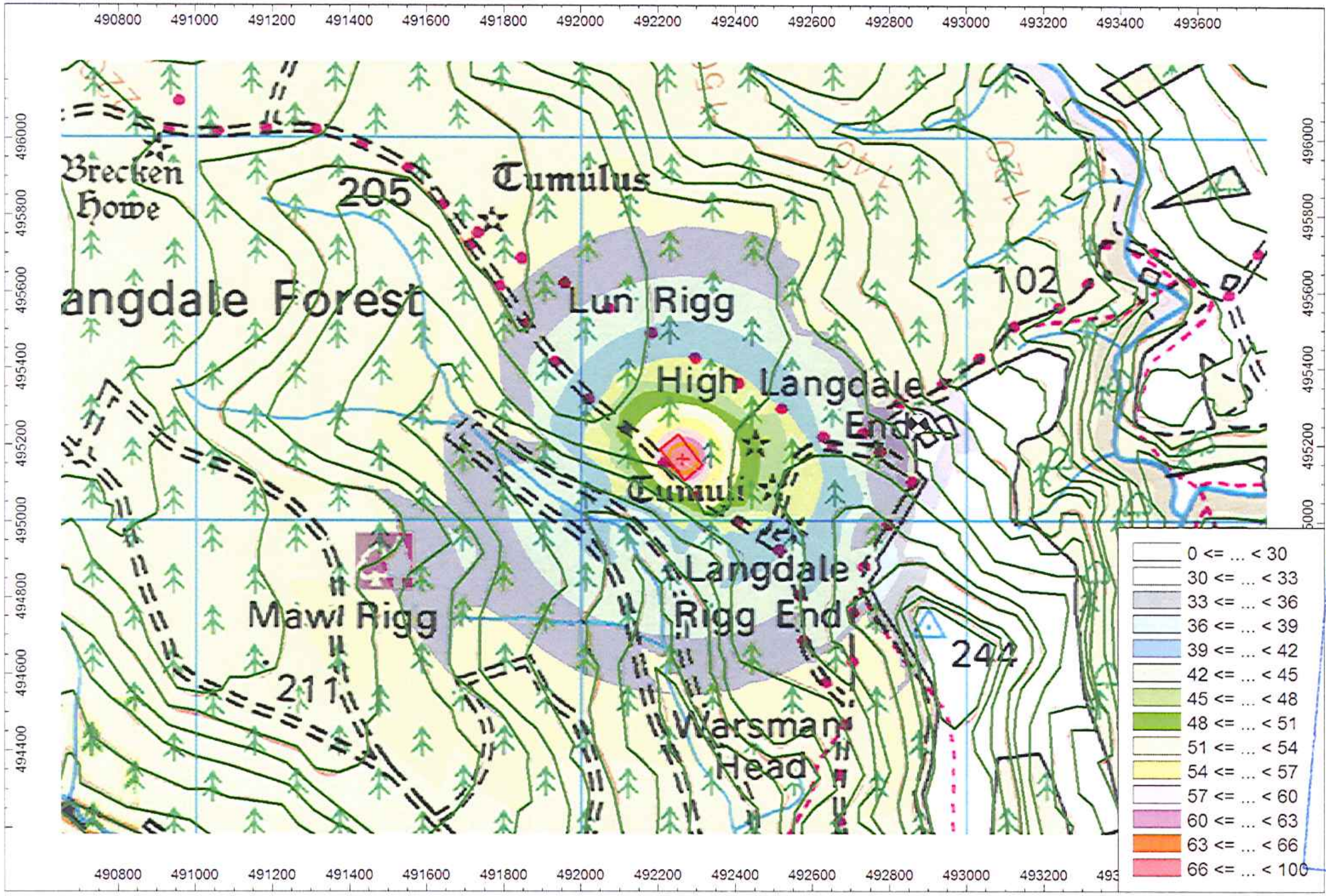
Appendix B Site Receptor Locations

FIGURE B1 SITE LOCATION AND LOCAL NOISE-SENSITVE RECEPTORS



Appendix C Noise Plot

FIGURE C1 DRILLING OPERATION NOISE PLOT, $L_{AEQ,T}$, dB(A) FREE-FIELD AT 1.5M ABOVE LOCAL GROUND

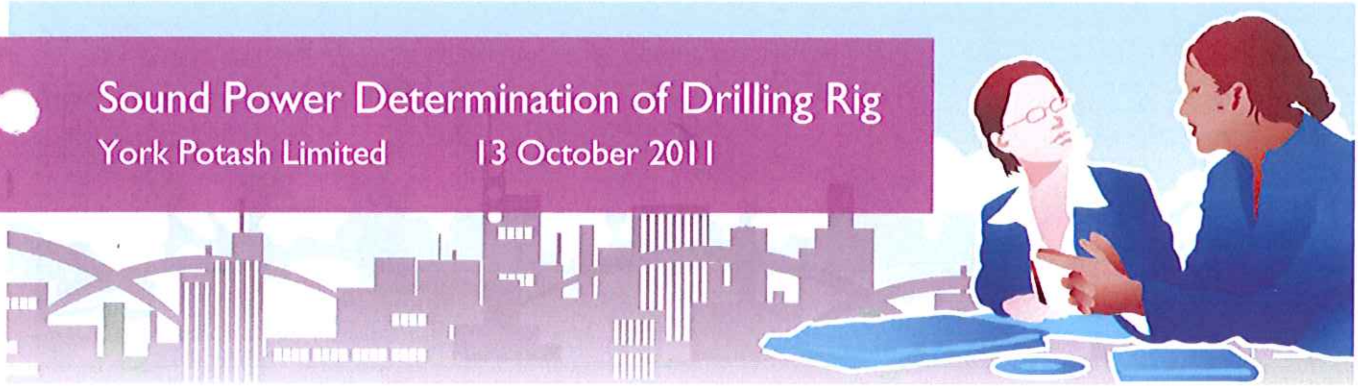


Appendix D Limitations

NOTES ON LIMITATIONS

This report has been prepared for the titled project or named part thereof and should not be used in whole or part and relied upon for any other project without the written authorisation of WSP Environmental Limited. WSP Environmental Limited accept no responsibility or liability for the consequences of this document if it is used for a purpose other than that for which it was commissioned. Persons wishing to use or rely upon this report for other purposes must seek written authority to do so from the owner of this report and/or WSP Environmental Limited and agree to indemnify WSP Environmental Limited for any and all loss or damage resulting therefrom. WSP Environmental Limited accepts no responsibility or liability for this document to any other party other than the person by whom it was commissioned.

The findings and opinions expressed are relevant to the dates of the site works and should not be relied upon to represent conditions at substantially later dates. Opinions included therein are based on information gathered during the study and from our experience. If additional information becomes available which may affect our comments, conclusions or recommendations WSP Environmental Limited reserve the right to review the information, reassess any new potential concerns and modify our opinions accordingly.



Addendum to WSP Acoustics Report Dated the 13 October 2011, Project Reference 19211/ Langdale Rigg End, and entitled, Langdale Rigg End – Potash / Polyhalite Drilling Noise Assessment.

Sound Power Determination of Marriott MI-45 Drilling Rig and Associated Mud Pump

13 October 2011

INTRODUCTION

This report constitutes an addendum to the previously completed noise assessment report as referenced above (which is hereafter referred to as the original noise assessment report). The original noise assessment report included a series of drilling noise level predictions which were undertaken based on the sound power level data provided for two of the drilling rigs being considered for use at this site.

The Marriott MI-45 drilling rig is also being considered for use at this site. Accordingly. WSP Acoustics has previously been commissioned by York Potash Limited to complete a series of noise measurements around this drilling rig and the associated mud pump at P R Marriott Drilling Limited's headquarters in Chesterfield.

The noise monitoring results have been used to determine sound power levels for each of these plant items and a brief comparison has been made with sound power levels adopted in the original noise assessment report, to determine whether the original noise assessment report conclusions remain valid.

NOISE SURVEY

General details

The noise survey was conducted on 7th July 2011 between 10:30 and 14:00 hours. Weather conditions during the survey were warm, with a light breeze. There was occasional light drizzle, however meteorological conditions were conducive to noise measurement.

Instrumentation

Details of the instrumentation used to measure noise levels have been provided below in Table 1.

Sound Power Determination of Drilling Rig

York Potash Limited 13 October 2011

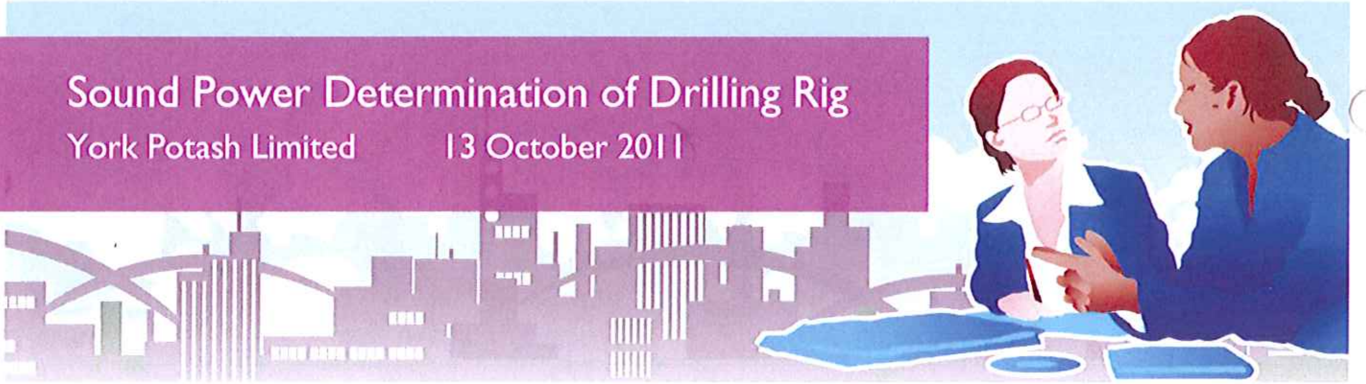


Table 1 Noise Monitoring Equipment Used (Type 1 Specification)

Equipment	Description	Serial Number
Sound Level Meter	01dB-METRAVIB Solo Master	60532
Pre-amplifier	01dB-Stell PRE 21 S	13150
Microphone	Microtech Gefell GmbH MCE212	65593
Sound Calibrator	01dB-Stell Cal 21	01120240

The sound level meter was calibrated before and after the survey and there was no drift in calibration observed.

Measurement Procedure

Measurements were carried out at the P R Marriott site in Chesterfield in one of their yards, away from building facades and other reflective surfaces. The ground condition was hard.

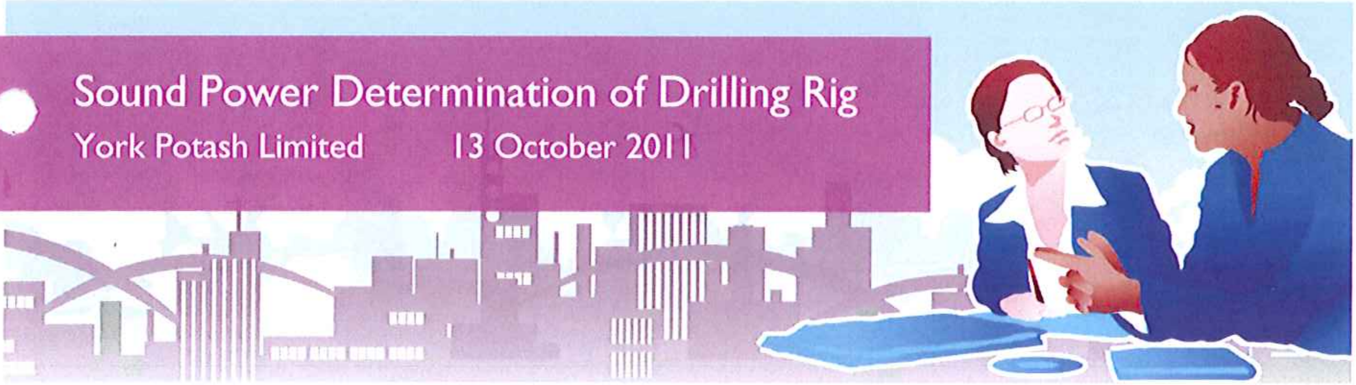
Two items of equipment were measured:-

- MI-45 Massenza Drilling Rig (Truck Mounted)
- F800 Mud Pump (Cummings KTA 38 G3 V12)

The equipment was operated across a range of duties and measurements were made at varying distances from the operating equipment. In each case, the microphone was positioned at 1.5m above ground level. In each measurement, the item of equipment was considered to dominate the ambient noise measurement at the microphone position.

Measurements were taken in 30 second L_{Aeq} values. L_{Aeq} is the equivalent continuous noise level and is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period. Octave band noise measurements were also taken.

In the case of the Drilling Rig, measurements were made at pre-selected distances from the four sides of the vehicle upon which the rig is mounted. In the case of the Mud Pump, measurements were made at pre-selected distances from the non-louvred side of the equipment. The louvred vertical end of the equipment housing did not radiate significant levels of noise and the other two sides were identical, both with access doors and some louvred sections. A series of check measurements was also undertaken on all sides, to confirm that the non-louvred side generated the highest noise levels.



Sound Power Determination of Drilling Rig

York Potash Limited 13 October 2011

It should be noted that during the noise measurements, the drilling mechanism was not in operation, but it was confirmed by the operator that this was not a dominant noise source when in operation. The dominant noise source was confirmed to be the drill power source, i.e. the diesel engine.

RESULTS

Table 2 shows a summary of the measurement results for the Drilling Rig based on data collected at distances of 10m and 20m.

In each case, the Sound Power has been derived from the measurement data assuming hemispherical radiation.

Table 2 Measurement Results for MI-45 Drilling Rig

Duty	10 metres from source		20 metres from source	
	Average $L_{Aeq,30sec}$ (dB)	Derived Sound Power L_w (dBA)	Average $L_{Aeq,30sec}$ (dB)	Derived Sound Power L_w (dBA)
25%	63.2	91.2	59.6	93.6
50%	66.4	94.4	62.2	96.2
75%	68.6	96.6	64.4	98.4
100%	70.9	98.9	67.0	101.0

Table 3 shows a summary of the measurement results for the Mud Pump based on data collected at distances of 10m and 20m.

As with the results from the Drilling Rig, the Sound Power has been derived from the measurement data assuming hemispherical radiation.

Table 3 Measurement Results for F800 (Cummings KTA 38 G3 V12) Mud Pump

Duty (rpm)	10 metres from source		20 metres from source	
	Average $L_{Aeq,30sec}$ (dB)	Derived Sound Power L_w (dBA)	Average $L_{Aeq,30sec}$ (dB)	Derived Sound Power L_w (dBA)
780	64.8	92.8	58.9	92.9
1070	66.3	94.3	60.1	94.1
1470	69.3	97.3	63.6	97.6

The octave band noise data for the derived sound power levels provided in Tables 2 and 3 are contained in Appendix A at the end of this report.

DISCUSSION

Table 2 shows that, when operating at 100% duty, the derived sound power level of the Drilling Rig is determined to be up to 101.0 dB(A). Table 3 shows that, when the Mud Pump is operating at 1470 rpm, its derived sound power level is determined to be up to 97.6 dB(A). Therefore the combined equivalent sound power level of the Drilling Rig and the Mud Pump is determined to be up to 102.6 dB(A).

It is understood that, in addition to these items of equipment, typical drilling operations may also require equipment such as shale shakers, generators and a centrifuge and such items will also generate a degree of noise.

The noise level calculations contained within the original noise assessment were based on noise emission data for the British Drilling and Freezing (BDF) Rig 28, the sound power of which was determined to be 109.6 dB(A) by Acoustic and Engineering Consultants (AEC) Ltd. The original noise assessment also identified that the BDF Rig 28 also has a similar sound power level as the Forraco BF831 rig (as determined by Spectrum Acoustics Ltd), which is also being considered for use at this site. The original assessment identified that the noise levels predicted to be generated by the proposed drilling works will be acceptable and will meet appropriate daytime, evening and night-time assessment criteria determined in accordance with a stringent interpretation of applicable national guidance.

In broad terms, the P R Marriott Drilling Limited equipment is circa 7 dB(A) quieter than the DBF Rig 28. As such the noise predictions previously conducted, and contained within the original noise assessment report, are considered to represent a worst case, and use of the PR Marriot rig as an alternative would yield even lower noise levels.

WSP Acoustics

Appendix A Octave Band Noise Sound Power Levels

Table A1 Sound Power Levels for MI-45 Drilling Rig

Duty	Location	Dist. (m)	A- weighted Noise Level, dB(A)	Octave Band Centre Frequency (Hz)								
				31.5	63	125	250	500	1 k	2 k	4 k	8 k
25%	Front	10	61.7	76.8	84.3	71.9	61.6	57.6	54.1	48.2	42.5	36.6
	Side 1	10	63.7	75.1	72.2	68.9	65.0	62.4	57.9	54.2	46.8	38.9
	Rear	10	59.5	73.1	83.2	65.9	60.5	54.5	53.4	48.0	38.9	35.3
	Side 2	10	65.6	77.8	81.9	70.5	65.1	62.0	61.6	57.0	47.7	39.4
	Average $L_{Aeq,30sec}$	10	63.2	76.0	82.1	69.8	63.5	60.2	58.0	53.5	45.2	37.9
	Power Level L_w		91.2	104.0	110.1	97.8	91.5	88.2	86.0	81.5	73.2	65.9
	Front	20	57.9	72.7	79.0	68.9	58.8	53.4	50.2	44.3	38.3	32.8
	Side 1	20	59.3	70.2	67.7	65.5	62.0	56.3	53.6	49.8	42.2	34.3
	Rear	20	57	75.4	80.5	63.8	58.9	52.5	50.0	45.3	38.2	34.7
	Side 2	20	62.2	73.5	76.4	67.3	64.5	59.8	57.1	52.5	44.1	35.7
	Average $L_{Aeq,30sec}$	20	59.6	73.3	77.8	66.8	61.7	56.5	53.7	49.2	41.4	34.5
	Power Level L_w		93.6	107.3	111.8	100.8	95.7	90.5	87.7	83.2	75.4	68.5
50%	Front	10	65.2	81.4	82.4	73.3	68.5	61.7	57.0	52.9	46.2	39.2
	Side 1	10	65.7	71.[illegible]	73.1	64.5	65.8	64.1	60.5	57.1	48.7	40.6
	Rear	10	62.1	73.8	77.8	68.9	65.2	58.3	56.5	51.5	40.9	34.9
	Side 2	10	69.5	76.1	80.0	71.4	69.3	66.4	64.9	61.5	51.8	44.3
	Average $L_{Aeq,30sec}$	10	66.4	77.4	79.7	71.1	67.5	63.6	61.1	57.5	48.4	41.0
	Power Level L_w		94.4	105.4	107.7	99.1	95.5	91.6	89.1	85.5	76.4	69.0
	Front	20	60.6	77.9	76.9	69.0	64.4	56.5	52.9	48.1	41.3	35.9
	Side 1	20	61.4	70.2	69.3	66.7	64.4	58.4	55.7	52.3	44.2	36.4
	Rear	20	59.5	73.0	76.6	68.8	62.9	55.0	52.0	46.5	37.4	32.9
	Side 2	20	65.1	73.6	76.9	67.6	67.5	61.9	59.7	56.2	46.9	38.7
	Average $L_{Aeq,30sec}$	20	62.2	74.6	75.8	68.1	65.1	58.8	56.2	52.4	43.7	36.4
	Power Level L_w		96.2	108.6	109.8	102.1	99.1	92.8	90.2	86.4	77.7	70.4

Sound Power Determination of Drilling Rig

York Potash Limited 13 October 2011

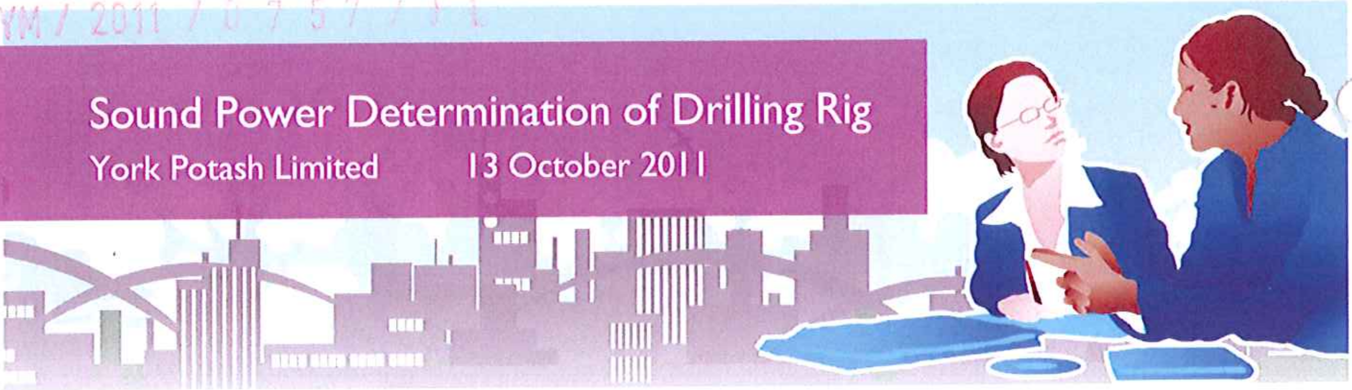


Table A1 Sound Power Levels for MI-45 Drilling Rig

Duty	Location	Distance (m)	A-weighted Noise Level, dB(A)	Octave Band Centre Frequency (Hz)								
				31.5	63	125	250	500	1 k	2 k	4 k	8 k
75%	Front	10	66.3	81.9	80.6	74.9	72.1	60.4	58.0	53.7	46.6	39.4
	Side 1	10	67.4	73.9	73.3	72.6	66.7	64.5	62.9	59.2	50.8	42.9
	Rear	10	63.7	73.4	77.4	69.0	64.6	61.7	58.7	54.4	44.5	36.7
	Side 2	10	72.3	81.9	77.6	71.5	74.0	70.9	66.7	64.5	55.3	48.2
	Average $L_{Aeq,30sec}$	10	68.6	79.5	77.9	72.5	70.9	66.5	63.0	60.2	51.2	43.9
	Power Level L_w		96.6	107.5	105.9	100.5	98.9	94.5	91.0	88.2	79.2	71.9
	Front	20	63.9	77.5	77.9	73.0	70.4	56.4	54.2	49.4	42.0	35.5
	Side 1	20	65	77.4	72.1	73.7	67.4	60.7	58.5	55.1	46.2	39.1
	Rear	20	60.5	73.9	73.8	66.5	63.8	58.0	55.7	49.3	40.5	34.1
	Side 2	20	66.4	79.0	70.8	68.0	68.8	63.2	60.8	59.0	50.4	42.9
	Average $L_{Aeq,30sec}$	20	64.4	77.3	74.5	71.3	68.2	60.3	58.0	55.1	46.5	39.3
	Power Level L_w		98.4	111.3	108.5	105.3	102.2	94.3	92.0	89.1	80.5	73.3
100%	Front	10	67.2	84.4	78.0	70.5	70.8	65.0	61.9	57.3	49.9	43.5
	Side 1	10	69.7	75.8	75.8	70.9	71.3	68.3	64.3	61.1	52.1	45.5
	Rear	10	65.9	72.2	77.7	71.4	68.8	62.0	61.3	56.1	46.6	39.1
	Side 2	10	74.8	83.9	79.5	74.4	73.8	73.1	69.9	67.0	56.8	50.8
	Average $L_{Aeq,30sec}$	10	70.9	81.6	77.9	72.1	71.5	69.0	65.8	62.6	52.9	46.7
	Power Level L_w		98.9	109.6	105.9	100.1	99.5	97.0	93.8	90.6	80.9	74.7
	Front	20	64.0	78.1	72.8	66.8	69.0	62.1	57.2	53.7	45.2	38.0
	Side 1	20	66.6	73.9	73.4	70.3	71.3	62.9	60.4	58.0	49.3	41.8
	Rear	20	62.8	74.4	74.5	68.5	65.6	61.1	57.2	52.0	42.8	35.3
	Side 2	20	70.5	80.2	76.0	69.7	76.2	66.1	64.5	61.0	52.6	45.5
	Average $L_{Aeq,30sec}$	20	67.0	77.4	74.4	69.0	72.2	63.5	60.9	57.6	49.0	41.8
	Power Level L_w		101.0	111.4	108.4	103.0	106.2	97.5	94.9	91.6	83.0	75.8

Table A2 Sound Power Levels for F800 (Cummings KTA 38 G3 V12) Mud Pump

Duty	Location	Distance (m)	A-weighted Noise Level, dB(A)	Octave Band Centre Frequency (Hz) 31.5	63	125	250	500	1 k	2 k	4 k	8 k
780	Side	10	64.6	81.7	85.1	69.1	60.3	59.1	58.9	55.8	45.4	38.1
	Front	10	65.0	76.9	81.5	68.6	63.4	57.5	62.3	56.0	42.7	32.7
	Average $L_{Aeq,30sec}$	10	64.8	79.9	83.7	68.9	62.1	58.4	60.9	55.9	44.3	36.2
	Power Level L_w		92.8	107.9	111.7	96.9	90.1	86.4	88.9	83.9	72.3	64.2
	Side	20	60.1	78.7	81.3	64.7	56.9	53.2	54.8	49.6	40.4	36.3
	Front	20	57.1	68.6	78.3	64.2	55.4	49.2	48.1	49.2	37.1	26.9
	Average $L_{Aeq,30sec}$	20	58.9	76.1	80.1	64.5	56.2	51.6	52.6	49.4	39.1	33.8
	Power Level L_w		92.9	110.1	114.1	98.5	90.2	85.6	86.6	83.4	73.1	67.8
1070	Side	10	66.4	70.5	83.2	71.7	68.1	59.5	60.5	60.6	48.3	38.8
	Front	10	66.1	80.0	80.4	75.5	69.7	59.8	58.7	59.3	47.7	39.5
	Average $L_{Aeq,30sec}$	10	66.3	77.5	82.0	74.0	69.0	59.7	59.7	60.0	48.0	39.2
	Power Level L_w		94.3	105.5	110.0	102.0	97.0	87.7	87.7	88.0	76.0	67.2
	Side	20	60.8	74.8	80.0	67.3	62.8	55.2	55.0	52.8	44.3	38.3
	Front	20	59.2	71.3	73.3	69.0	62.1	54.1	49.7	52.3	41.3	34.3
	Average $L_{Aeq,30sec}$	20	60.1	73.4	77.8	68.2	62.5	54.7	53.1	52.6	43.1	36.7
	Power Level L_w		94.1	107.4	111.8	102.2	96.5	88.7	87.1	86.6	77.1	70.7
1470	Front	10	68.9	78.9	81.4	80.2	73.3	62.8	59.2	59.2	50.1	40.9
	Side	10	69.6	78.0	89.5	78.0	69.4	63.1	61.4	62.7	50.4	42.6
	Average $L_{Aeq,30sec}$	10	69.3	78.5	87.1	79.2	71.8	63.0	60.4	61.3	50.3	41.8
	Power Level L_w		97.3	106.5	115.1	107.2	99.8	91.0	88.4	89.3	78.3	69.8
	Front	20	62.8	75.2	78.0	74.6	67.5	55.8	51.1	52.5	43.5	35.2
	Side	20	64.2	74.1	83.0	73.9	65.7	57.9	57.1	55.7	45.1	38.1
	Average $L_{Aeq,30sec}$	20	63.6	74.7	81.2	74.3	66.7	57.0	55.1	54.4	44.4	36.9
	Power Level L_w		97.6	108.7	115.2	108.3	100.7	91.0	89.1	88.4	78.4	70.9