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THE EXCESS ATTENUATION OF ENVIRONMENTAL NOISE SOURCES THROUGH A DENSELY PLANTED FOREST

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1.0 INTRODUCTION

A major oil exploration company propose to carry out drilling operations at and in the immediate vicinity of existing Well Sites within a densely wooded area.

The noise calculation methodologies used to predict the potential noise levels from the drilling operations do not take account of the possible additional attenuation effect from the densely wooded areas in the vicinity of the wellsite. The methodologies take into account geometric spreading, ground and air absorption and also the effect of any barriers; the effect of trees is considered to be additional to these factors. Therefore, it is considered that the prediction study carried out for the drilling operations may result in an over-estimate of the receiver noise levels at properties in the vicinity located at a closest-distance of 500 metres where the propagation is through trees.

The object of the study was to identify the potential additional attenuation from trees so that an estimation of the effect on the predicted noise levels occurring from the drilling operations could be identified.

This is a measurement based study, the results are therefore particularly site specific and pertinent to the whole noise impact study for the area.

The purpose in utilising a noise measurement study was based on the difficulty in placing any great level of confidence in previous theoretical and measurement studies.

In particular the theoretical studies e.g. R Bullen, 'Sound propagation through vegetation'. [1] which require an estimation of the tree density, the scattering and absorbing cross sections etc and other measurement studies such as the Transport Research studies (2,3) are site specific and relate to a line source.

2.0 METHOD OF STUDY

2.1 Introduction

The measurement study was undertaken during calm weather conditions.

Sound pressure levels were measured at five locations spread linearly from a sound power source mounted on a hydraulic 'cherry picker' (elevated platform). At each of the receiver locations two sets of measurements were taken; one set with the microphone 1.5m above ground level and one set with the microphone at a height of 4.5m. The sampling locations were situated at 50m, 100m, 200m, 400m and 500m from the noise source. The first two locations were in clear sight of the noise source whilst the locations at 200, 400 and 500 m were situated in coniferous woodland.

2.2 Site and Surroundings

The area in which the study was conducted lies between the north-western point of the wellsite perimeter fence and the most sensitive receiver. The intervening land consisted mainly of coniferous woodland traversed by rough tracks used for forestry.

The noise source used was a Bruel & Kjaer Type 4224 portable sound source. The noise source was operated from heights of 2m, 4m, 8m and 10m above ground level in order to simulate the heights of the main sound generating components of the proposed. The sound power output was set at 115 dB and was monitored throughout the course of the study using a Lucas Instruments CEL Environmental Noise Monitor type 262. The microphone was fixed in position 1m from the noise source for all four noise source heights.

Location 1

This site is in a flat grassy area planted with saplings of up to 1.5m height which do not obstruct the view of the microphone at either of its heights for any of the four noise source heights used.

Location 2

This site is situated just within the border of the coniferous woodland. At both microphone heights the view of the four noise source positions is completely unobstructed.

Location 3

This site is 200m from the noise source which cannot be seen at any of its four heights. The location is completely surrounded by dense vegetation including rhododendron bushes, conifers, bracken, hazel and assorted wetland flora.

Location 4

This location is situated some 30m into a regularly arranged conifer plantation 400m from the noise source. The lack of low hanging branches and underbrush in addition to the fact that the rows of conifers line up in the direction of the noise source give a clear view of the dense flora that surrounds location 3.

Location 5

At 500m from the noise source, this location is situated at the edge of a track separating the plantation containing location 4 from other plantations to the north east. Again the noise source cannot be seen from this location.

2.3 Meteorological Conditions

During the noise surveys, meteorological conditions were generally stable and good for noise measurements.

Very light winds were recorded in the northeast direction; the maximum recorded speed was 0.6 ms^{-1}.

The sky was overcast, cloud cover was considered to be 90%. The Pasquill Stability class was determined to be class D. Combining both the Pasquill Stability and wind speed in the direction of the measurement locations, it was determined that the CONCAWE(4) meteorological category was 5.

The mean air temperature was 10°C and the humidity was 95%.

Meteorological conditions were monitored using a whirling hygrometer and a thermo-anemometer.

2.4 Study Procedure

Before commencing the surveys the sound level meters were calibrated. A maximum change of 0.1 dB was noted on the meter over the duration of the surveys; this change can be considered insignificant and the results are therefore considered to be accurate to $\pm$0.5 dB.

The Lucas Instruments CEL Environmental Noise Analyser Type 262 was used to obtain the Equivalent Continuous Noise Level L_{Aeq} for 10 second periods randomly chosen during the course of the study in order to ensure that the noise source output remained constant

The measurements at locations 1-5 were taken using Rion NA-29E Sound Level Meters with a built in octave band analyser. These instruments were used to give the sound pressure level for each octave band from 31.5 Hz to 8 kHz in addition to giving the Equivalent Continuous Noise level L_{eq}. Measurements were taken over a twenty second period.

Microphones were mounted upon a unipod which was set to the ground for 1.5m measurements and held aloft for 4.5m measurements.

A repeat set of measurements were obtained at both receiver heights for locations 3, 4 and 5.

Background noise levels were measured throughout the study. Noise level measurements were not recorded when the sound power source did not exceed the background noise levels by 10 dB in each octave band.

3.0 RESULTS

Figures 1 and 2 depict the measurements obtained during the study compared against the values predicted using the CONCAWE model. The differential between the values measured and those predicted is considered to be due to a combination of the attenuation provided by the woodland and conservativeness of the acoustic model underpredicting the air and ground attenuation. The results of these calculations for location 5 (receiver distance 500m) are summarised below in Table 1 and 2.

Table 1: Additional Attenuation due to Woodland: Receiver height 1.5m, 500m from noise source.

Source Height (m)	Attenuation (dB) for Octave Band Centre Frequency (Hz)						
	63.5	125	250	500	1k	2k	4k
2	3.2	9.7	2.35	-2.15	9.4	21.7	24.65
4	9.2	8.6	-4.25	-4.95	8.4	21.15	24.45
8	11.5	6.35	-0.7	1	10.1	21.85	22.7
10	12.4	8.35	3.2	1.4	9.95	18.6	22.05
MEAN	**9.1**	**8.3**	**0.2**	**-1.2**	**9.5**	**20.8**	**23.5**

Table 2: Additional Attenuation due to Woodland: Receiver height 4.5m, 500m from source

Source Height (m)	Attenuation (dB) for Octave Band Centre Frequency (Hz)						
	62.5	125	250	500	1k	2k	4k
2	11.1	0.7	-1.95	0.3	11.2	19.3	18.3
4	10.7	3.6	-5.4	-3.2	15.5	20.95	21.7
8	11.2	0.35	-5.6	-0.9	8.9	20.95	21.8
10	12.3	1.85	-2.75	0.4	7.75	16.85	21.65
MEAN	**11.3**	**1.6**	**-3.9**	**-0.9**	**10.8**	**19.5**	**20.9**

4.0 DISCUSSION

4.1 Sound Power Source

The sound power spectrum of the noise source was determined by deriving the mean sound power level from sixteen noise level measurements carried out at 50m and 100m from the noise source. For each measurement, the sound power level was calculated from the CONCAWE noise prediction model. There were no obstructions between source and receiver enabling a simple calculation of the power level.

The standard deviation error between the mean sound power level and each individual predicted sound power level was considered to give a degree of confidence in the consistency of the generated signal from the sound power source for each measurement.

For frequencies at and above 250 Hz the confidence limits are good, having an error below 3 dB. Below 250 Hz however the margin of error increases to 4.5 dB.

It should be noted that whilst the values for sound power levels are given for the octave bands 31.5 Hz and 8 kHz, these frequencies are at the edge of the generated spectrum and not considered to be as steady state as the remaining octave bands measured. The results for 31.5 Hz and 8 kHz cannot be considered as accurate.

4.2 Attenuation Derivation

The sound power spectrum was then used to predict the noise levels at locations 3-5 for the octave bands between 250 Hz and 4 kHz. These predictions assume that there are no barriers to sound propagation between the noise source and receivers.

Comparing the results of the CONCAWE predictions (meteorological category 5) against the measured values for locations 3-5, the first impression is that the amount of additional attenuation increases with an increase in source height. This however is considered to be a result of under prediction of the attenuation by the noise model. The model will have predicted little ground attenuation at a 10m source height when this may in fact not be the case. Conversely, but more unlikely, the model may have over predicted the ground attenuation at the 2m source height. This is not considered likely because the ground in the woodland was covered in leaf litter and foliage and is likely to be highly absorptive.

For some receiver heights with sound level measurements in the frequency band range 250 - 500 Hz there is less attenuation than would be expected. This is considered to be a function of the octave band frequency curves within the CONCAWE model overpredicting the attenuation expected at these two octave bands.

It can be seen that attenuation at frequencies below 250 Hz and above 2 kHz is very good; this is to be expected and is due to the barrier effects of the trees and absorption properties of the needles and leaves both tree-bound and exfoliated.

The degree of additional attenuation experienced at the 500m receiver location will be dependent upon the noise spectrums generated by the proposed drilling rig plant. The trees between the drilling site and the receiver location will have a significant effect on the noise sources with sound energy dominant in the octave bands of 63-125 Hz and 1-4 kHz. For noise sources where the majority of sound energy is emitted in the octave bands 250-500 Hz then the trees are considered to give little additional attenuation.

The majority of the sound energy generated by the drilling rig specified for drill sites F and M is emitted in the middle and lower end of the noise spectrum below 2 kHz. Whilst a large percentage of the noise generated by the drilling rig is produced in the mid frequency range 250-500 Hz, where little additional attenuation can be expected from the woodland, there will still be a significant increase in attenuation from that predicted by conventional acoustic environmental models.

5.0 CONCLUSIONS

1. The attenuation calculated for a distance of 500m from the noise source is not constant across the spectrum.

2. It is considered that the CONCAWE noise propagation model underpredicts attenuation through the woodland for the octave bands 63 Hz, 125 Hz, 1 kHz, 2 kHz and 4 kHz. The maximum additional attenuation is 22 dB at 4 kHz.

3. The CONCAWE model accurately predicts the attenuation with distance for the centre frequency octave bands 250 Hz and 500 Hz.

6.0 REFERENCES

1. R Bullen 'Sound propagation through vegetation' JSV (1982) 80 (1).

2. L Huddart, 'The use of vegetation for traffic noise screening' TRL RR 238 (1990).

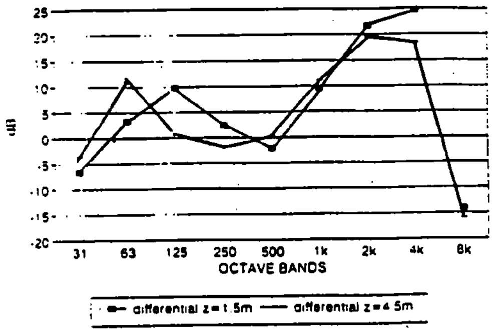
3. D G Harland, 'Rural traffic noise prediction - an approximation' TRRL SR 425 (1978).

4. CONCAWE 'The propagation of noise from petroleum and petrochemical complexes to neighbouring communities'. Report No 4/81 (1981).

EXCESS ATTENUATION IN FORESTS

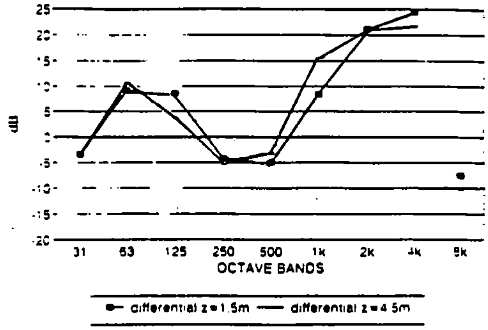
PREDICTED SPECTRA v MEASURED

DIFFERENTIAL:Source=2m, y=500m



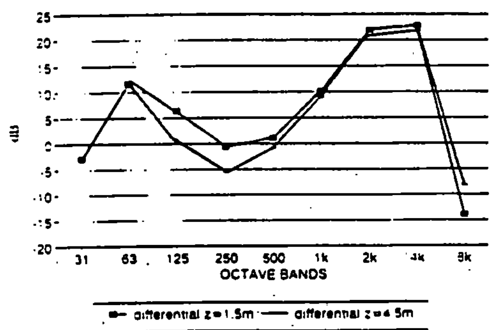
PREDICTED SPECTRA v MEASURED

DIFFERENTIAL:Source=4m, y=500m



PREDICTED SPECTRA v MEASURED

DIFFERENTIAL:Source=8m, y=500m



PREDICTED SPECTRA v MEASURED

DIFFERENTIAL:Source=10m, y=500m