Community Noise Investigation of a "Low Level Thrumming" Attributed to the Operation of a Mine

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1 Introduction

In May 2016, RWDI/Wakefield Acoustics was asked by the operator of a mine to investigate noise complaints from a resident living 2.7 km from the mine. The mine produces concrete aggregate, construction materials and specialty blended sands. The major sources of noise at the mine during the time period of interest are conveyors and rock crushers. The resident reported experiencing the noise during the nighttime and early morning hours in their bedroom and described the noise as a "low level thrumming that increases in intensity when lying down in bed with my head on a pillow". The operator of the mine was surprised by these complaints as the mine equipment largely shuts down between 23:00 and 24:00. To investigate the noise complaints, RWDI/Wakefield Acoustics conducted continuous noise monitoring at the home of the resident, the mine and various locations in the community to establish the frequency spectra of mine noise emissions, observe the variations in mine noise levels, and determine if the mine frequency spectra and noise level variations correlated with the noise data collected in the community.

2 Methodology

2.1 Noise Monitoring

Noise monitoring was conducted at the mine and five other locations in the surrounding community. The key monitoring sites discussed in this paper are the mine (site 1), the home of the resident (site 2) and a "control site" at a nearby home on the same street as the resident (site 3). The sound level meter at the mine was placed in an elevated position with a clear line of sight to the noise sources (i.e. conveyors, crushers). As the resident had been experiencing the noise in the bedroom at the back of their house, the sound level meters at sites 2 and 3 were placed in the backyards.

The noise monitoring was carried out with Bruel & Kjaer 2250 and Larson Davis LxT sound level meters (SLM). Noise level data were logged in 15-minute intervals and the primary data collected were the A- and C-weighted L_{eq} and one-third octave band levels.

2.2 Noise Criteria

The World Health Organization (WHO) community noise thresholds[1] were used too assess the severity of mine noise at the resident's home (assuming mine noise was detectable). The WHO criteria are summarized in **Table 1**. The presence of low-frequency noise was assessed using the criteria recommended in the Health Canada (HC) 2011 Draft Noise Guidelines[2]. The HC document considers low-frequency noise to be present when the difference between C- and A-weighted levels is 10 dBA or more. HC also recommends that the energetic-sum of the sound levels in the 16, 31.5 and 63 Hz octave bands not exceed 70 dB to avoid rattling building structures.

Table 1: WHO Community Noise Thresholds

Environment	Health Effect	L_{eq} (dBA)
Outdoor Living Area	Serious annoyance, daytime and evening;	55
	Moderate annoyance, daytime and evening	50
Dwellings, indoors	Speech intelligibility and moderate annoyance, daytime and evening;	35
	Sleep disturbance, nighttime	30
Dwellings, outdoors	Sleep disturbance, window open (outdoor values)	45

3 Results

3.1 Average Noise Levels (A-weighted L_{eq})

Table 2 presents the A-weighted L_{eq} measured during time periods when the mine was fully operating, partially operating and shut down.

Table 2: L_{eq} for Different Periods of Mine Operation

Site	Approximate L_{eq} (dBA)		
	Fully Operating (18:00-00:30)	Partially Operating (00:45-2:30)	Shutdown (2:30-3:30)
1	61	45	39
2	40	25	35
3	39	27	37

From **Table 2**, it can be seen that noise levels at the residences (sites 2 and 3) did not exceed the WHO thresholds. While the L_{eq} at the residences were highest when the mine was fully operating, the higher noise levels were not necessarily due to mine operation. Rather, noise would generally be expected to be higher during the evening than during the early morning hours due to the presence of community noise sources such as road traffic, aircraft and marine vessels. When the field engineer visited the residences at approximately 23:00 mine noise was not observed to be audible relative to the background noise environment that was composed of natural sounds such as ocean waves breaking on the shore.

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3.2 Low-Frequency Noise

Table 2 presents the C-weighted noise levels at the residence (sites 2 and 3) for different phases of mine operation and also presents the differences between the C-weighted and A-weighted levels.

Table 3: Low-Freq. Noise Levels for Different Periods of Mine Operation

Site	Mine Operation	L_{eq} (dBA)	L_{eq} (dBC)	Diff. (dB)
2	Full	40	55	15
	Partial	25	51	26
	Shutdown	35	46	11
3	Full	39	51	12
	Partial	27	45	18
	Shutdown	37	42	5

When the mine was operating (full and partial), the differences in the C- and A-weighted noise levels exceeded the HC 10 dB criterion at both sites. When the mine was shutdown, however, the criterion was only exceeded at site 2. The sum of the noise levels in the 16, 31.5 and 63 Hz one-third octave bands did not exceed the 70 dB rattle criterion at either residence.

3.3 Frequency Spectra

Figure 1 shows the one-third octave band frequency spectra measured at sites 1, 2 and 3 when the mine was partially operating.

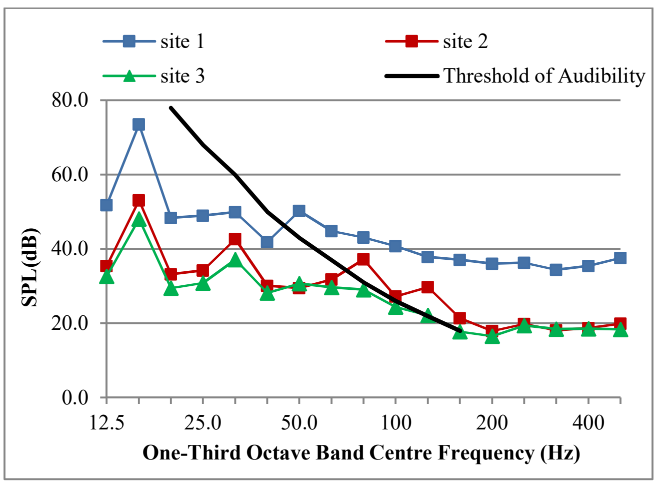

Figure 1: Frequency Spectra when Mine Partially Operating

In **Figure 1** it can be seen that at all three sites there is a prominent tone in the 16 Hz one-third octave band which, being most intense at the mine, was concluded to be due the operation of the mine. This tone, however, was both too low in frequency and sound pressure level to be audible by the average human ear. At site 2 there were also tones in the 80 and 125 Hz one-third octave bands which would be expected to be audible. As these tones were not present in the frequency spectra at the mine (site 1) it was concluded that they must be originating from a source other than the mine. In further support of this hypothesis, the tones were found to be present at site 2 even when the mine was shutdown. Interestingly, these tones were not present at the neighboring home (site 3). These results suggest that the tones are being emitted by a source(s) in close proximity to the resident's home. As these tones are above the threshold of audibility, it is possible that they are causing the resident's noise disturbance.

To further investigate the nature of these tones, time histories were created of the sound pressure levels in the 80 and 125 Hz one-third octave bands. The 125 Hz time history (**Figure 2**) was particularly interesting as it revealed a cyclical pattern at the resident's home (site 2) that is consistent with intermittently operating mechanical equipment (e.g. heat pump).

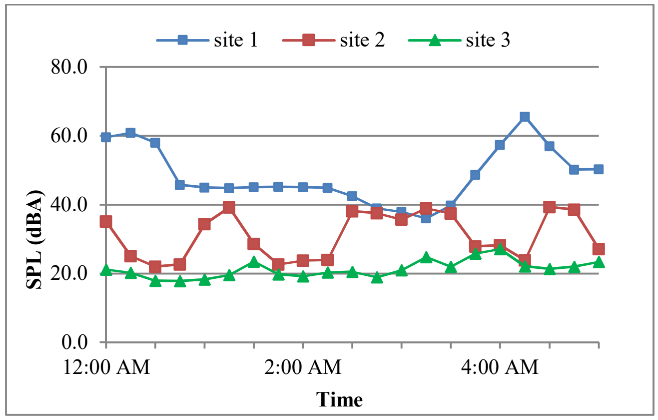

Figure 2: 125 Hz Time History

4 Conclusion

The results of the community noise investigation suggest that the noise being experienced by the resident is due to source(s) other than the Lehigh mine. Outdoor noise levels at the resident's home are within the thresholds of WHO community noise guidelines. While low-frequency noise from the mine was found to be present at the resident's home, the noise was largely at frequencies and sound pressure levels below the range of average human hearing.

The outdoor frequency spectra at the resident's home contains tones in the 80 and 125 Hz one-third octave bands that are at audible levels. It is suspected that these tones are what the resident is hearing. These tones were absent from the frequency spectra measured at the mine, and are present even when the mine is shutdown. As these tones were also absent from the frequency spectra measured at a neighboring residence (site 3), the source(s) of these tones are likely in close proximity to the resident's home.

References

1. World Health Organization. *Guidelines for Community Noise*. 1999
2. Health Canada. *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise (Draft).* 2011