3 METHODS

24-hour surveys were conducted at each of the three locations described in Section 2. Surveys of this type and duration provide information on daily variability in noise levels as well as providing an expected typical or average daily condition.

3.1 MONITORING METHODS

Model 2250 Brüel and Kjaer Type I integrating sound level meters were used to collect the measurements and sound recordings. The meter logs noise levels and records audible sound over a set monitoring period selected by the user. The logging rate was set for one minute and the monitoring period was set for 24 hours (sound recordings were saved every ten minutes).

Data parameters logged every minute for the survey periods included:

- integrated average (L_{Aeq}) in dBA;
- 1/3 octave band values in dB;
- absolute maximum (L_{AFmax}) in dBA; and
- minimum (L_{AFmin}) values over one-minute intervals.

A Brüel and Kjaer Type 4231 Calibrator was used for calibrating the meters before and after each 24-hour monitoring period to ensure the noise meter variance was within 0.5 dB. The calibrator has an estimated uncertainty for sound pressure level of ±0.12 dB at a 99% confidence level.

In this survey, weather data were derived from the permanent weather station situated along the north-shore of Doris Lake, which is located in the region of the noise monitoring sites. The station recorded hourly wind, temperature, humidity, and precipitation data. Temperature, wind speed, and wind direction were also recorded at the beginning and end point of each monitoring sequence using a Kestrel 2500 pocket weather meter.

Direct observations and field notes made by the study team recorded precipitation, cloud cover, wind direction, and observed audible noise sources.

3.2 DATA ANALYSIS APPROACH

Recorded sound level and audio sound were downloaded to a computer for analysis with the Brüel and Kjaer 7820 Evaluator® software program. The sound recordings were reviewed to identify noise sources, such as technician activities, wind, rain, construction, and helicopter noise Hourly values were then calculated for the 24-hour measurements from the one-minute data. Other indicators used to identify sources of noise were time of day and field observations.

4 RESULTS

The measurement data collected for the study are presented in this section. Noise sources that were not representative of expected, typical ambient conditions (e.g., helicopter fly-by, technician activity, or animal interference) were excluded from the calculated hourly daytime or night-time results. All L_{eq}, L_{90}, and L_{max} "hourly" values are based on at least 30 minutes of data.

The following definitions will aid the non-technical reader:

- L_{eq} is the continuous equivalent sound level over a time period.
- L_{90} is the 90^{th} percentile level where 90% of the measurement time period has exceeded the stated sound level. For example, an L_{90} of 80 dBA means that the sound pressure level exceeded 80 dBA during 90% of the measurement period. L_{90} is usually regarded as the residual level, or the background noise level without discrete events.
- L_{max} is the maximum value recorded during that hourly period.

4.1 JETTY AND QUARRY AREA 1 (NM-1)

NM-1 is located at the jetty and quarry area south of Roberts Bay. The meter was situated 50 m south-west of the construction pad. The construction pad is located south of the Jetty area. During the monitoring period, there was construction activity around the clock (teams work in 12 h shifts). The landscape was relatively flat and consisted of Roberts Bay to the north and soft dirt ground with vegetation south of the site. The monitoring surface was clay-like, soft marine sediments.

Hourly, maximum, minimum, and logarithmic average L_{eq}, L_{90}, and L_{max} results of the 27-hour survey are shown in Table 4.1. One-minute noise levels and sources of peaks are shown graphically in Figure 4.1. The isolated events (e.g., helicopter) in the hourly calculations are identified in the figure.

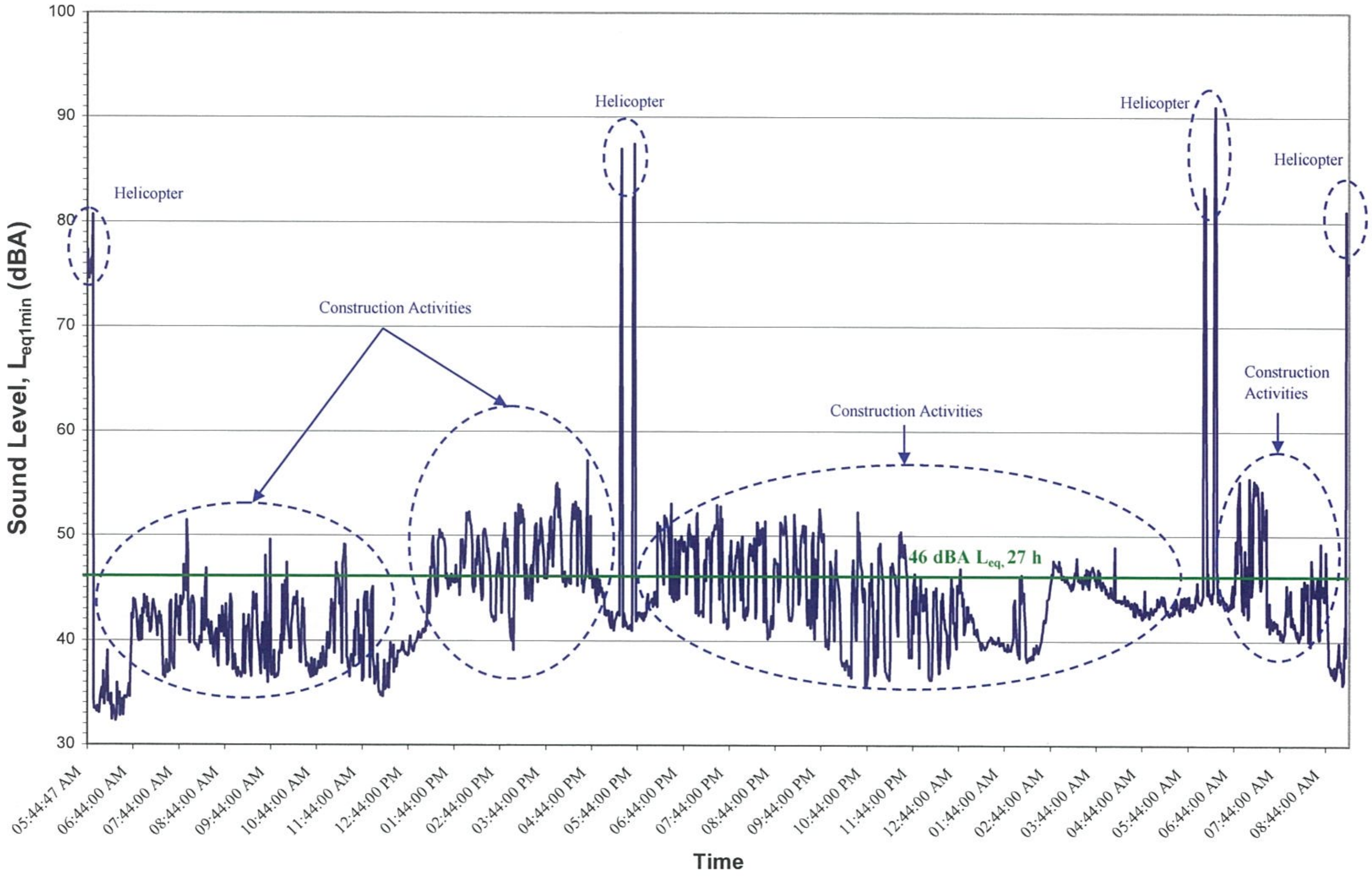
General sources of noise observed or recorded at this location were helicopter and camp construction activities. Peaks were caused by helicopters landing and taking off during shift change or noise technician arrival. The variability of noise levels noted in the graph was due to the construction activities and wind.

Table 4.1 Hourly Sound Levels, Site NM-1

Date	Hour	Sound Level [dBA]		
		L_{eq}	L_{90}	L_{max}
July 25, 2007	6:00 AM	39	36	59
July 25, 2007	7:00 AM	43	40	66
July 25, 2007	8:00 AM	41	39	64
July 25, 2007	9:00 AM	41	37	75
July 25, 2007	10:00 AM	41	38	55
July 25, 2007	11:00 AM	43	39	61
July 26, 2007	12:00 PM	38	37	62
July 26, 2007	1:00 PM	47	44	62
July 26, 2007	2:00 PM	48	45	62
July 26, 2007	3:00 PM	50	46	65
July 26, 2007	4:00 PM	49	45	65
July 26, 2007	5:00 PM	42[(a)]	41[(a)]	60[(a)]
July 26, 2007	6:00 PM	49	45	62
July 26, 2007	7:00 PM	48	44	63
July 26, 2007	8:00 PM	48	44	62
July 26, 2007	9:00 PM	47	44	60
July 26, 2007	10:00 PM	44	41	61
July 26, 2007	11:00 PM	45	42	60
July 26, 2007	12:00 AM	43	40	56
July 26, 2007	1:00 AM	40	39	51
July 26, 2007	2:00 AM	44	42	55
July 26, 2007	3:00 AM	46	45	53
July 26, 2007	4:00 AM	44	42	62
July 26, 2007	5:00 AM	43	42	60
July 26, 2007	6:00 AM	47[(a)]	44[(a)]	62[(a)]
July 26, 2007	7:00 AM	49	44	63
July 26, 2007	8:00 AM	43	40	60
maximum		50	46	75
minimum		38	36	51
logarithmic average		46	43	64

(a) Measurement has been isolated from helicopter noise; however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

Figure 4.1 One - Minute Noise Levels, NM-1, July 25 and 26, 2007



The L_{eq} range (maximum – minimum) of 12 dBA and the L_{90} range of 10 dBA represent moderate noise fluctuation in the environment. The minimum L_{90} value of 36 dBA occurs before the startup of construction activities for the day shift crew. This sound level is indicative of the ambient noise level in the jetty area without any construction activities. The 27-hour logarithmic average of 46 dBA (L_{eq}) provides a realistic single value representation of the current ambient level near the Jetty area.

4.2 CAMP AND PLANT AREA (NM-2) AND QUARRY #2 (NM-3)

NM-2 and NM-3 are located in the area north of Doris Lake, southwest of the rock outcrop known as Doris mesa. The meter was located in a clearing between NM-2 and NM-3. The surrounding landscape was characterized by Doris Lake in the south, relatively flat terrain in the north and west, and Doris mesa in the east. Ground coverage was rocky with some vegetation.

The noise monitoring was conducted for a total of 49 hours during two time periods. Time Period 1 consisted of 27 hours between 6:00 AM (July 25, 2007) and 9:00 AM (July 26, 2007). Time Period 2 consisted of 22 hours between 9:00 AM (July 26, 2007) and 7:00 AM (July 27, 2007). The creation of two consecutive time periods was due to a memory card change in the sound level meter. Hourly, maximum, minimum, and logarithmic average L_{eq}, L_{90}, and L_{max} results of the 49-hour survey are shown in tables 4.2 and 4.3. One-minute noise levels and sources of peaks are shown graphically in figures 4.2 and 4.3. The isolated events (e.g., helicopter) in the hourly calculations are identified in the figures.

General sources of noise observed or recorded at this location were helicopter activities, animal noise (muskox, birds), and wind noise. Peaks were caused by helicopter landing and taking off during shift change or noise technician arrival. The variability of noise levels noted in the graph is primarily due to weather conditions, such as wind and rain.

The L_{eq} range (maximum – minimum) was 14 dBA during Time Period 1 and 16 dBA during Time Period 2. The L_{90} range was 11 dBA during Time Period 1 and 13 dBA during Time Period 2. The range difference indicates more noise fluctuation during Time Period 2 when the average wind speed per hour was consistently higher. The logarithmic average of 30 dBA (L_{eq}) and 24 dBA (L_{90}) during Time Period 1 represents low ambient noise level without the helicopter traffic and high wind.

Table 4.2 Time Period 1 Hourly Sound Levels, NM-2 and NM-3, July 25 and 26, 2007

Date	Hour	Sound Level [dBA]		
		L_{eq}	L_{90}	L_{max}
July 25, 2007	6:00 AM	28[(a)]	23[(a)]	44[(a)]
July 25, 2007	7:00 AM	28	22	48
July 25, 2007	8:00 AM	29[(a)]	23[(a)]	47[(a)]
July 25, 2007	9:00 AM	33	26	62
July 25, 2007	10:00 AM	32	26	47
July 25, 2007	11:00 AM	27[(a)]	22[(a)]	49[(a)]
July 25, 2007	12:00 PM	28	22	49
July 25, 2007	1:00 PM	34	26	53
July 25, 2007	2:00 PM	33	26	51
July 25, 2007	3:00 PM	30	22	49
July 25, 2007	4:00 PM	31	23	49
July 25, 2007	5:00 PM	33[(a)]	23[(a)]	61[(a)]
July 25, 2007	6:00 PM	29	23	45
July 25, 2007	7:00 PM	26	20	49
July 25, 2007	8:00 PM	25	20	43
July 25, 2007	9:00 PM	21	18	46
July 25, 2007	10:00 PM	21	18	31
July 25, 2007	11:00 PM	21	19	34
July 26, 2007	12:00 AM	24	21	48
July 26, 2007	1:00 AM	22	20	35
July 26, 2007	2:00 AM	26	23	41
July 26, 2007	3:00 AM	31	25	45
July 26, 2007	4:00 AM	26	22	50
July 26, 2007	5:00 AM	27	22	44
July 26, 2007	6:00 AM	35[(a)]	29[(a)]	51[(a)]
July 26, 2007	7:00 AM	32	27	46
July 26, 2007	8:00 AM	33[(a)]	28[(a)]	47[(a)]
maximum		35	29	62
minimum		21	18	31
logarithmic average		30	24	52

(a) Measurement has been isolated from helicopter noise; however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

Table 4.3 Time Period 2 Hourly Sound Levels, NM-2 and NM-3, July 26 and 27, 2007

Date	Hour	Sound Level [dBA]		
		L_{eq}	L_{90}	L_{max}
July 26, 2007	9:00 AM	32[a]	26[a]	49[a]
July 26, 2007	10:00 AM	31	25	48
July 26, 2007	11:00 AM	35[a]	29[a]	50[a]
July 26, 2007	12:00 PM	39	33	52
July 26, 2007	1:00 PM	40	33	54
July 26, 2007	2:00 PM	42[a]	35[a]	58[a]
July 26, 2007	3:00 PM	41[b]	35[b]	56[b]
July 26, 2007	4:00 PM	37[a]	30[a]	56[a]
July 26, 2007	5:00 PM	40[a]	33[a]	58[a]
July 26, 2007	6:00 PM	42[a]	34[a]	64[a]
July 26, 2007	7:00 PM	40	33	58
July 26, 2007	8:00 PM	37	31	55
July 26, 2007	9:00 PM	35	28	56
July 26, 2007	10:00 PM	30	25	46
July 26, 2007	11:00 PM	28	24	46
July 27, 2007	12:00 AM	28	23	51
July 27, 2007	1:00 AM	26	22	45
July 27, 2007	2:00 AM	27	23	46
July 27, 2007	3:00 AM	28	24	45
July 27, 2007	4:00 AM	30	24	46
July 27, 2007	5:00 AM	34	27	51
July 27, 2007	6:00 AM	39[a]	31[a]	53[a]
maximum		42	35	64
minimum		26	22	45
logarithmic average		37	31	55

[a] Measurement has been isolated from helicopter noise; however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

[b] Measurement has been isolated from muskox noise; however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

Figure 4.2 Time Period 1 One- Minute Noise Levels, NM-2 and NM-3, July 25 and 26, 2007

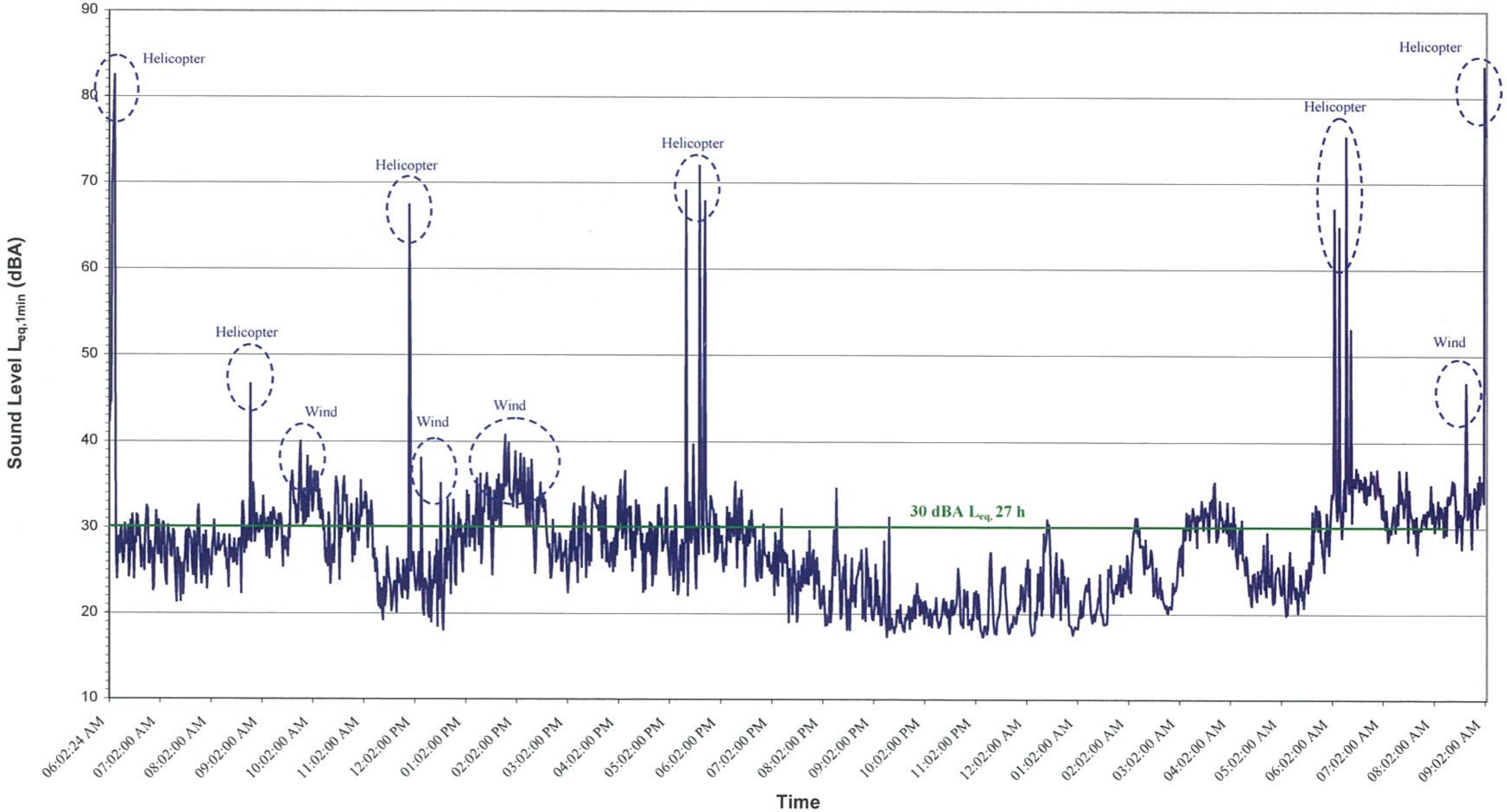
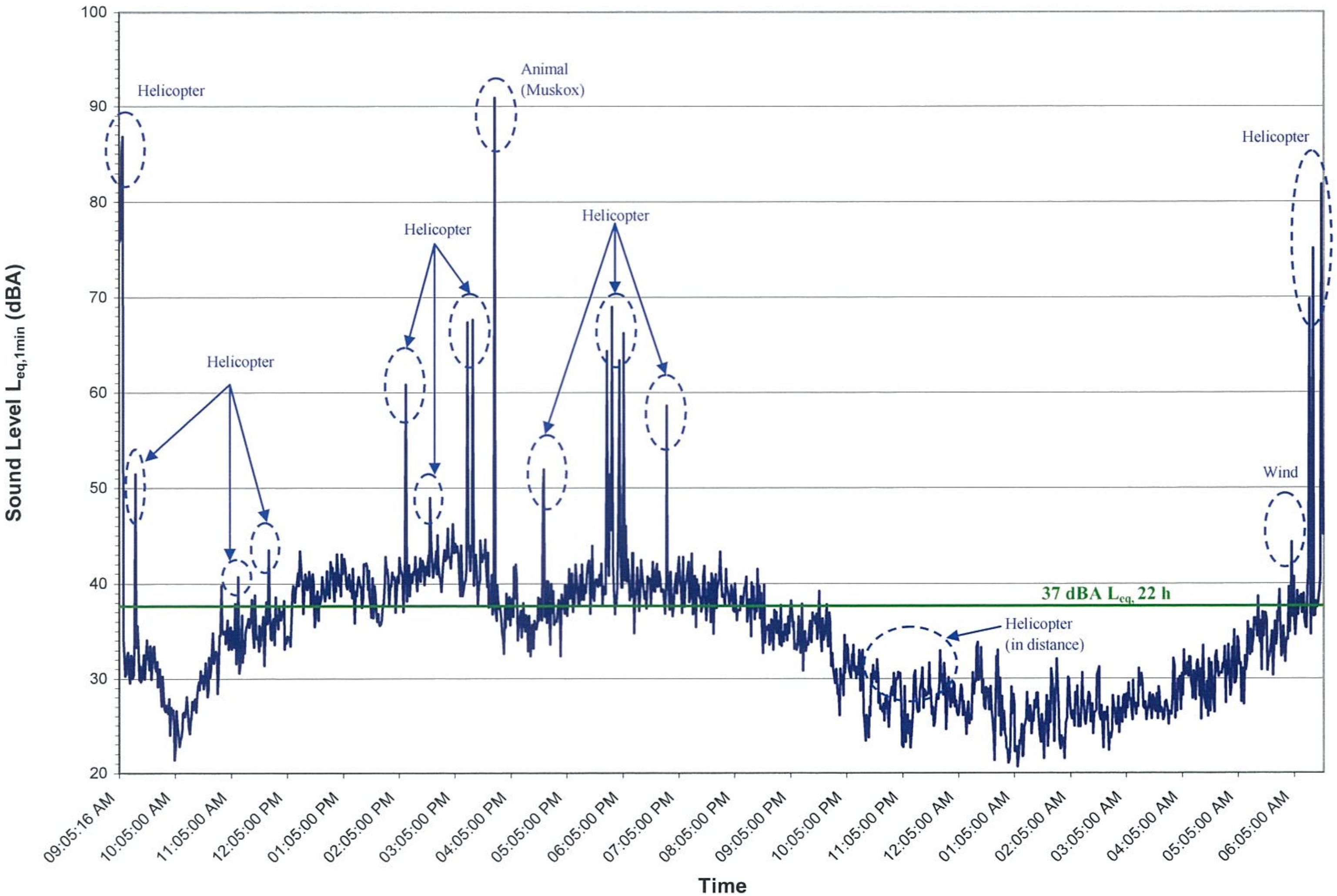


Figure 4.3 Time Period 2 One- Minute Noise Levels, NM-2 and NM-3, July 26 and 27, 2007



4.3 TAILINGS AREA/CARIBOU CROSSING (NM-4)

NM-4 is located in the south east end of Tail Lake. The monitor was located approximately 50 m from the lakeshore. The landscape surrounding the site was relatively flat and consisted of the lake and rock outcrops. The surface that monitoring was conducted on was rocky with some vegetation.

Hourly, maximum, minimum, and logarithmic average L_{eq}, L_{90}, and L_{max} results of the 20-hour survey are shown in Table 4.4. One-minute noise levels and sources of peaks are shown graphically in Figure 4.4. The isolated events (e.g., helicopter) in the hourly calculations are identified in the figure.

General audible observations and recordings at this location indicate noise from wind, helicopter activities, birds, and waves lapping along the lakeshore. The one-minute noise levels ranged between 28 and 96 dBA. The peaks were due to helicopter activities, birds, and wind noise.

The L_{eq} range (maximum – minimum) was 19 dBA and the L_{90} range was 14 dBA during the measurement period. The considerably higher L_{eq} range difference values is due to the higher wind and wave noise during the time period of 4:00 PM to 8:00 PM July 26, 2007. The logarithmic average of 47 dBA (L_{eq}) and 41 dBA (L_{90}) represents higher ambient noise level when compared to other pristine environments (e.g., 25 dBA to 35 dBA). The 6 dBA difference between L_{eq} and L_{90} indicates moderate noise fluctuation in this location.

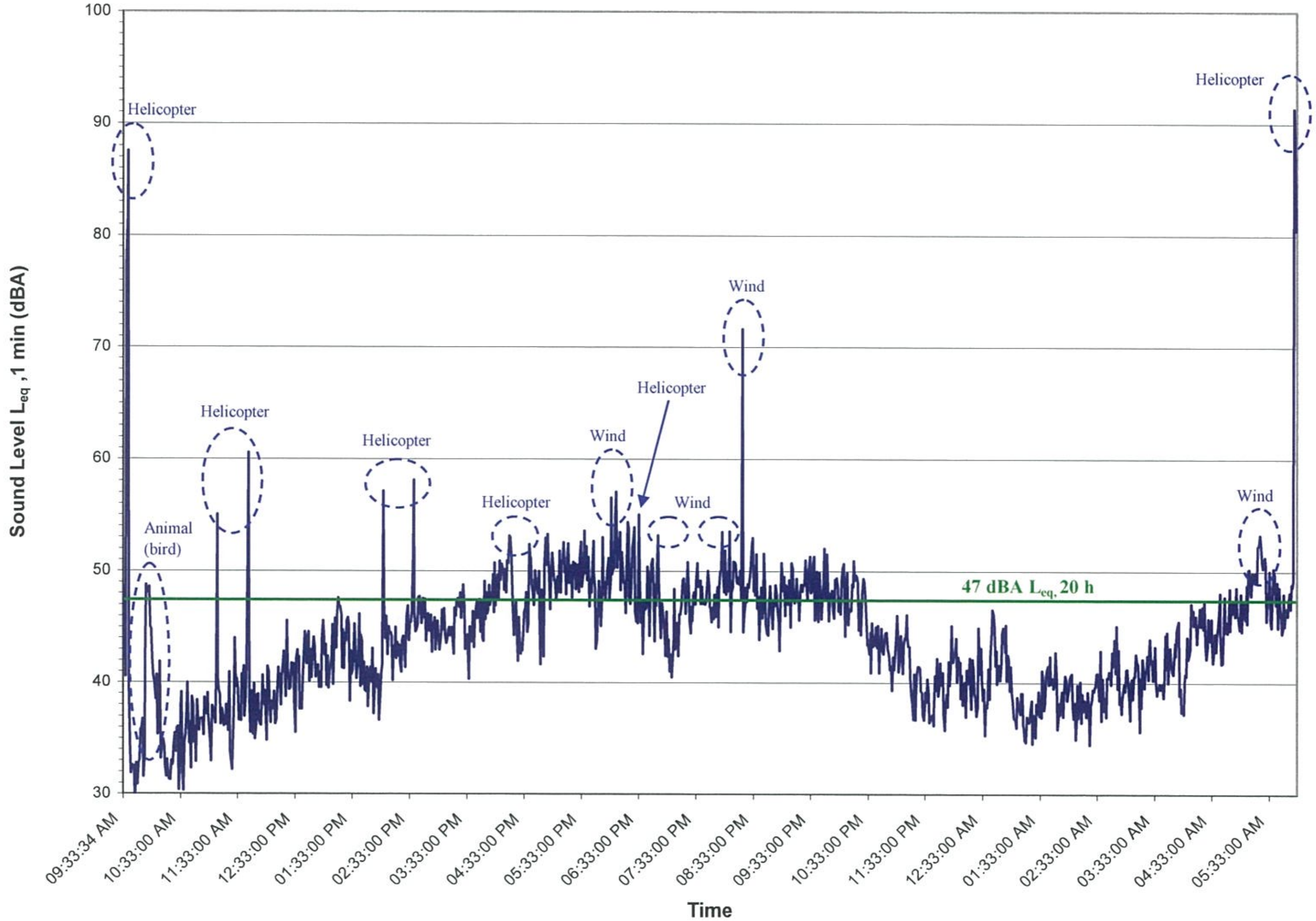
Table 4.4 Hourly Sound Levels, NM-4, July 26 and 27, 2007

Date	Hour	Sound Level [dBA]		
		L_{eq}	L_{90}	L_{max}
July 26, 2007	10:00 AM	36[(a)]	30[(a)]	61[(a)]
July 26, 2007	11:00 AM	38[(b)]	34[(b)]	58[(b)]
July 26, 2007	12:00 PM	41	36	59
July 26, 2007	1:00 PM	43	38	59
July 26, 2007	2:00 PM	45[(b)]	40[(b)]	59[(b)]
July 26, 2007	3:00 PM	46	40	59
July 26, 2007	4:00 PM	48[(b)]	43[(b)]	62[(b)]
July 26, 2007	5:00 PM	50	44	66
July 26, 2007	6:00 PM	50[(b)]	44[(b)]	71[(b)]
July 26, 2007	7:00 PM	47	42	64
July 26, 2007	8:00 PM	55	43	64
July 26, 2007	9:00 PM	49	44	64
July 26, 2007	10:00 PM	47	41	61
July 26, 2007	11:00 PM	41	36	55
July 27, 2007	12:00 AM	42	37	55
July 27, 2007	1:00 AM	39	35	52
July 27, 2007	2:00 AM	40	35	54
July 27, 2007	3:00 AM	41	37	54
July 27, 2007	4:00 AM	45	40	60
July 27, 2007	5:00 AM	49[(b)]	43[(b)]	63[(b)]
maximum		55	44	71
minimum		36	30	52
logarithmic average		47	41	62

(a) Measurement has been isolated from bird noise (on microphone); however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

(b) Measurement has been isolated from helicopter noise; however, the value represents less than 60 minutes but more than 30 minutes of recorded data.

Figure 4.4 One - Minute Noise Levels, NM-4, July 26 and 27, 2007



5 WEATHER CONDITIONS

The weather conditions were recorded by a permanent weather station located at the northwest corner of Doris Lake. Air temperature, wind speed, wind direction, and humidity data were recorded by the weather station. Table 5.1 presents the data for the time period during the noise measurement.

Table 5.1 Weather Information

Date	Hour	Weather Information				
		Mean Horizontal Wind Speed (km/h)	Unit Vector Mean Wind Direction [a] (degrees)	Average Air Temperature (° Celsius)	Humidity (%)	Notes
July 25, 2007	6:00 AM	18	290	8	94	periodic light drizzle, overcast, low cloud ceiling
July 25, 2007	7:00 AM	16	303	8	90	
July 25, 2007	8:00 AM	18	301	8	89	
July 25, 2007	9:00 AM	18	296	9	88	
July 25, 2007	10:00 AM	18	285	9	93	
July 25, 2007	11:00 AM	13	357	10	82	
July 25, 2007	12:00 PM	17	23	11	75	
July 25, 2007	1:00 PM	23	18	11	79	
July 25, 2007	2:00 PM	21	26	10	84	
July 25, 2007	3:00 PM	24	31	9	88	
July 25, 2007	4:00 PM	21	22	10	82	
July 25, 2007	5:00 PM	21	18	10	81	
July 25, 2007	6:00 PM	20	10	9	91	
July 25, 2007	7:00 PM	20	30	9	89	
July 25, 2007	8:00 PM	14	32	9	92	
July 25, 2007	9:00 PM	12	9	9	91	
July 25, 2007	10:00 PM	14	347	9	89	
July 25, 2007	11:00 PM	12	300	9	93	
July 26, 2007	12:00 AM	15	297	8	94	
July 26, 2007	1:00 AM	18	304	9	93	
July 26, 2007	2:00 AM	21	321	9	92	
July 26, 2007	3:00 AM	25	328	9	90	
July 26, 2007	4:00 AM	20	324	8	89	precipitation stop, periodic strong gusty wind
July 26, 2007	5:00 AM	24	327	9	86	
July 26, 2007	6:00 AM	24	318	9	83	
July 26, 2007	7:00 AM	24	288	10	83	
July 26, 2007	8:00 AM	24	290	11	79	

Table 5.1 Weather Information (continued)

Date	Hour	Weather Information				
		Mean Horizontal Wind Speed (km/h)	Unit Vector Mean Wind Direction [(a)] (degrees)	Average Air Temperature (° Celsius)	Humidity (%)	Notes
July 26, 2007	9:00 AM	19	289	11	80	precipitation stop, periodic strong gusty wind
July 26, 2007	10:00 AM	21	287	13	71	
July 26, 2007	11:00 AM	23	289	13	71	
July 26, 2007	12:00 PM	27	286	14	68	
July 26, 2007	1:00 PM	25	280	14	65	
July 26, 2007	2:00 PM	25	275	14	67	
July 26, 2007	3:00 PM	28	272	13	71	
July 26, 2007	4:00 PM	35	270	12	69	
July 26, 2007	5:00 PM	33	272	12	69	
July 26, 2007	6:00 PM	32	273	12	68	
July 26, 2007	7:00 PM	31	274	11	72	
July 26, 2007	8:00 PM	29	273	10	77	
July 26, 2007	9:00 PM	26	279	9	82	
July 26, 2007	10:00 PM	23	289	8	85	
July 26, 2007	11:00 PM	24	292	8	86	
July 27, 2007	12:00 AM	24	292	8	87	
July 27, 2007	1:00 AM	24	289	8	89	
July 27, 2007	2:00 AM	27	290	7	92	
July 27, 2007	3:00 AM	32	293	6	95	
July 27, 2007	4:00 AM	34	291	6	96	
July 27, 2007	5:00 AM	35	286	6	96	
July 27, 2007	6:00 AM	35	286	6	94	

[(a)] 0 or 360 degree represents the true north direction.

6 SUMMARY

Table 6.1 summarizes the resulting average L_{eq} and L_{90} sound levels from the noise surveys at the three locations. The results show the potential variability in ambient noise levels for the four locations (NM-1 to NM-4) identified for the Project.

The higher ambient level at NM-1 and NM-4 was influenced by different factors. The ambient level at NM-1 is influenced by the construction activities in the surrounding area. The ambient level at NM-4 is contributed by the high wind and waves along the lake shore. Ambient level was lowest at NM-2 and NM-3; however, the level was also influenced by the higher wind during the second day (Time Period 2) of measurement.

Table 6.1 Summary of Ambient Sound Levels

Site	Time Period (hours)	L_{eq} (dBA)	L_{90} (dBA)
Jetty and Quarry #1 Area (NM-1)	27	46	43
Camp and Plant Area (NM-2) and Quarry #2 (NM-3) Time Period 1	27	30	24
Camp and Plant Area (NM-2) and Quarry #2 (NM-3) Time Period 2	22	37	31
Tailing Area/Caribou Crossing (NM-4)	20	47	41

7 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

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8 REFERENCES

Cowan, James P. 1994. Handbook of Environmental Acoustics. John Wiley & Sons

APPENDIX A

NOISE TERMINOLOGY

NOISE TERMINOLOGY

Since the concepts and theories used in the assessment of outdoor acoustics are not intuitive, the following descriptions of key concepts and definitions used in this evaluation are provided to guide the reader:

"Sound" or "sound emissions" refers to the acoustic energy generated by natural or man-made sources, including the Project activities.

"Noise" or "noise levels" refers to the levels that can be heard or measured at a receiver.

A noise "receiver" is a location where measurements or predictions of noise levels are made.

The "volume" of a sound or noise is expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a sound or noise that is twice as loud as another will only be three decibels (3 dB) higher. A sound or noise with double the number of decibels is much more than twice as loud. A change of three decibels is also the general theshold at which a person can notice a change in sound volume.

Sound emissions and noise levels also have a "frequency". The human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while low and high frequencies are harder to hear. Environmental noise levels are usually presented as "A weighted" decibels (or dBA), which incorporates the frequency response of the human ear. While low frequency noise may not be "heard", it can often be felt.

"Sound power" is the rate of acoustic energy flow across a specified surface, or emitted by a specified sound source. The sound power in a frequency band is the energy flow rate associated with sound frequencies lying within the band.

"Sound power level" is the level of sound power, expressed in decibel (dB) relative to a stated reference value of 1 pW (dB re 10^{-12} W).

"Sound pressure" is the difference between the instantaneous pressure at a fixed point in a sound field, and the pressure at the same point with the sound absent.

"Sound pressure level" is the sound pressure at a given point quantified by:

$$L_p = 10\ \log_{10}(p_{rms}/p_{ref})^2$$

Where p_{rms} is the root mean square, sound pressure and p_{ref} is the reference rms sound pressure (dB re 20μPa).

"Equivalent noise level" (L_{eq}) is the continuous equivalent sound level, defined as the sound pressure level that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period. This type of average takes into account the natural variability of sound. L_{eq} is a common descriptor used in outdoor noise measurement (Cowan 1994).

"Percentile noise level" (L_n), where *n* is any number between 0 and 100, represent the sound level that has been exceeded for the *n* percentage of time period. For example, L_{90} = 70 dBA represents sound pressure level measurements exceeding 70 dBA for 90% of the measurement period. The most commonly used L_n values are L_1, L_{10}, L_{50}, and L_{90}. L_1 is considered as the average maximum noise level when readings are 1 hour or less in duration. L_{10} is usually regarded as an indication of truck traffic noise with a steady flow sound level. L_{50} provides an indication of median sound level. L_{90} is usually regarded as the residual level, or the background noise level without the source in question or discrete events (Cowan 1994).

APPENDIX B

FIELD PHOTOGRAPHS

Photos B.1 NM-1 Jetty and Quarry #1 Area Noise Monitoring Setup (July 25 to 26, 2007)