



# **Portable Noise Monitoring Report**

**March 5 - April 24, 2016**

**The Museum of Vancouver**

Vancouver Airport Authority

September 27, 2016

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## INTRODUCTION

This report summarizes the results from the deployment of the Vancouver Airport Authority's portable noise monitoring terminal in the City of Vancouver (the Kitsilano area) from March 5 through April 24, 2016. The monitoring site, located at the Museum of Vancouver (specifically 1100 Chestnut St, Vancouver, BC) was selected in consultation with City of Vancouver staff and through discussions with the YVR Aeronautical Noise Management Committee.

The portable Noise Monitoring Terminal ("NMT") is a Brüel & Kjær Environmental Monitoring Unit 2 (EMU), which is linked to the Vancouver Airport Authority's Aircraft and Operations Management System ("ANOMS"). The portable NMT was placed on the roof of the Museum in a secure location.

## OBJECTIVES

The objective of this noise monitoring study is to understand and collect baseline information on the current aircraft noise exposure in the area. The noise data and analysis from this study will also provide a baseline to determine and assess potential noise implications associated with the future use of the Required Navigation Performance (RNP) approach procedure for Runway 08L. Details of the RNP approach procedure for Runway 08L can be found on the noise management section of the YVR website (<http://www.yvr.ca/en/about-yvr/noise-management>).

This study follows the same methodology as in previous monitoring efforts and includes various noise metrics to describe the measured noise levels. Results of this study are meant for information purposes only. They are not meant to initiate changes to the airspace or aircraft procedures over the area or to be used for the purpose of monitoring compliance with aircraft noise regulations. All aircraft operating in Canada meet noise standards prescribed by the International Civil Aviation Organization (ICAO).

## VANCOUVER: AIRCRAFT OPERATIONS

Figure 1 and 2 illustrate the typical flight patterns in relation to the monitoring location at the Museum of Vancouver. The figures represent radar flight tracks over a typical four-hour period (10AM-2PM) during Runway 26 operations (westerly traffic flow) and Runway 08 operations (easterly traffic flow) at YVR, respectively. The green tracks represent aircraft departing from YVR, the red tracks represent aircraft arriving at YVR, and the blue tracks represent non-YVR aircraft operating from other airports in the region.

The monitoring site is located near the long established downwind flight path, which is used to properly sequence and space aircraft on their approach to the airport. This downwind path is used mainly by aircraft arriving from a northern and western direction during Runway 26 operations as well as aircraft arriving from a northern and eastern direction during Runway 08 operations. The average altitude of these aircraft over the area around the Museum of Vancouver is approximately 7,000 feet during Runway 26 operations and approximately 8,000 feet during Runway 08 operations.

Non-YVR aircraft traffic is also common over and near the monitoring site. These aircraft operate from other airports or water aerodromes in the Lower Mainland and generally operate at lower altitudes between 1,000 and 3,000 feet when over the area.

Figure 1: Typical Flight Tracks when Runways 26L and 26R are Active at YVR

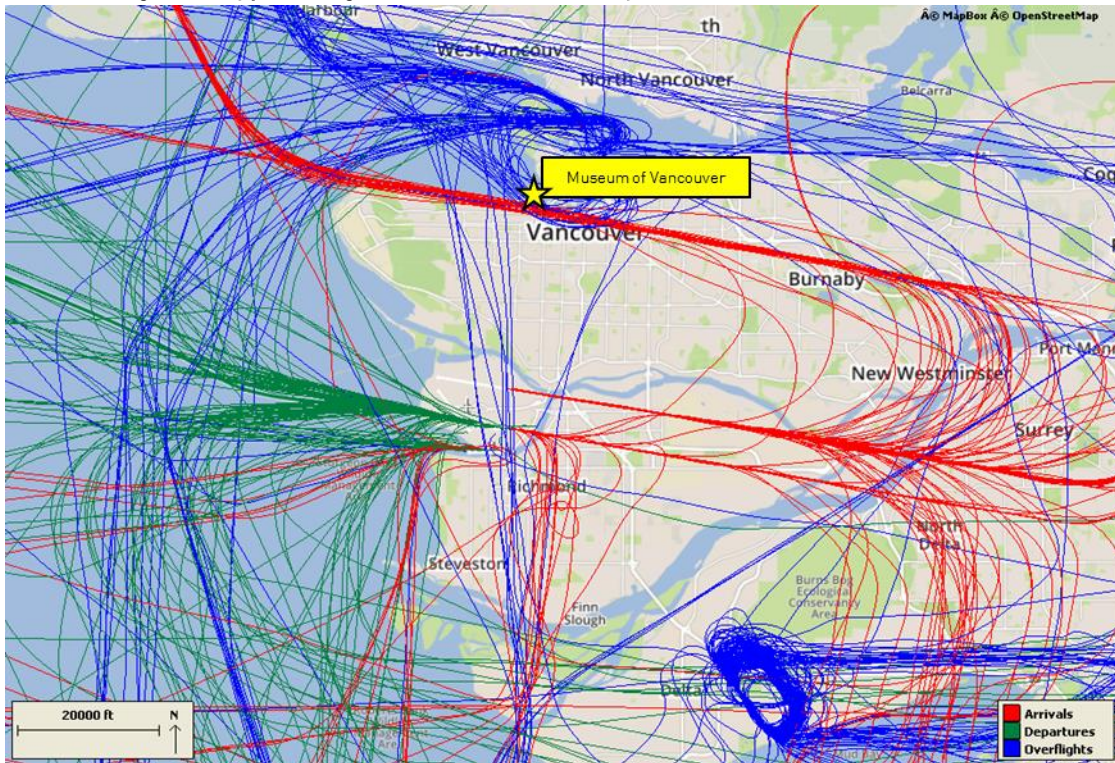
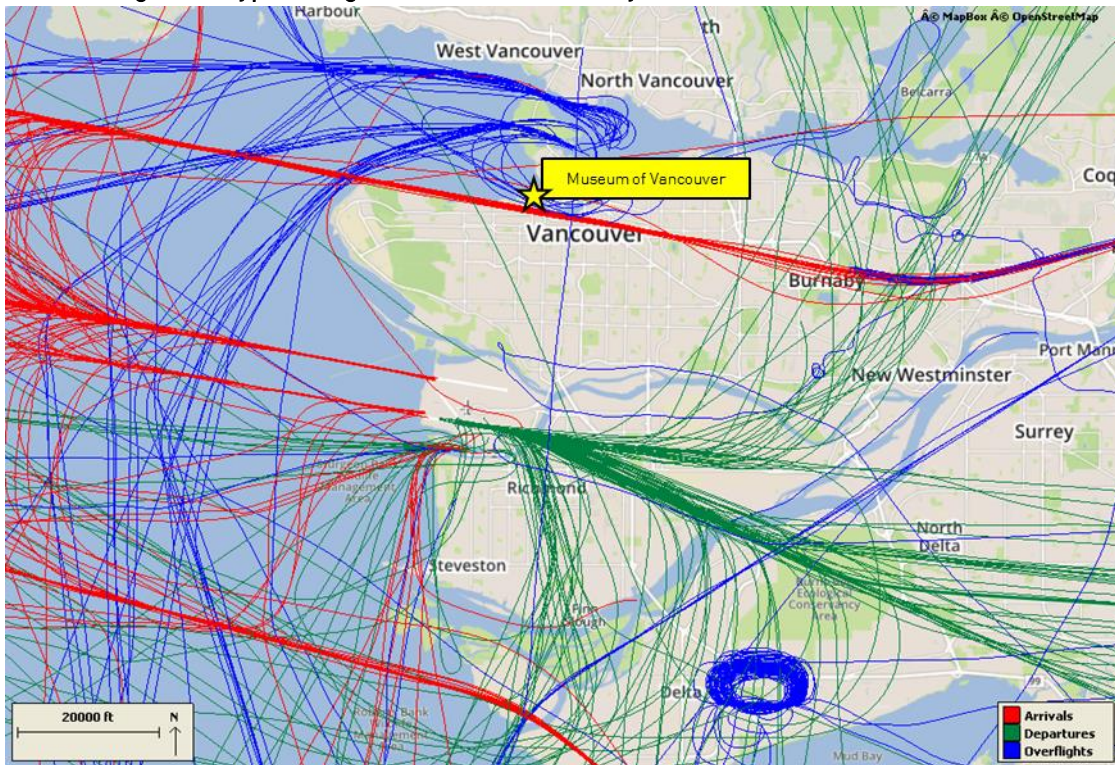


Figure 2: Typical Flight Tracks when Runways 08L and 08R are Active at YVR



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## METHODOLOGY

### EQUIPMENT SET-UP AND CALIBRATION

The portable NMT was set up on the roof of the Museum of Vancouver and positioned away from any large sound reflecting surfaces such as walls, trees, and other significant sources of community noise (see Figure 3). The microphone was fitted with a windscreen and set on top of a tripod. The NMT was stored in a locked waterproof case adjacent to the microphone and power was supplied from the Museum. An initial calibration was performed using a piston phone at the beginning of monitoring as is standard practice. The portable NMT was calibrated and adjusted for 0.2 dBA of drift. An automatic electrostatic calibration is also performed on a nightly basis throughout the monitoring period.

### MONITORING

The collection of noise data commenced on March 5 and ceased on April 24, 2016<sup>1</sup>, a period of 51 days. The NMT is designed to continually measure sound levels from all sources at the location, including aircraft, vehicles, and all other community noise sources.

**Figure 3: Portable NMT Set-up at the Museum of Vancouver (facing North)**



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<sup>1</sup> The monitoring period began on March 5 at 0000 hours and ended at 2359 hours on April 24, 2016.

## DEFINING NOISE EVENTS

A noise event is captured by the NMT when the sound level exceeds a predefined threshold for a set duration of time. For these measurements, the event thresholds were set at:

Time Period	Sound level Threshold	Event Duration
7:00AM – 10:00PM	65 dBA or greater	6 seconds
10:00PM-7:00AM	55 dBA or greater	6 seconds

The sound thresholds are set according to the ambient background noise level in the community, and the lower threshold at night accounts for the reduced ambient background noise. Noise events can be caused by either aircraft or non-aircraft sources. The ANOMS system will use algorithms to correlate those noise events caused by aircraft flying in close vicinity to the NMT location using radar data supplied by NAV CANADA. This allows the Airport Authority to determine the contribution of aircraft noise in the area compared to other community noise sources.

## RESULTS

### NOISE EVENTS

Over the 51-day monitoring period, a total of 2,674 noise events were registered at the site. Of these events, 25% (n=676) were associated with aircraft, and the remaining 75% (n=1,998) were identified as coming from other community noise sources.

Of the number of events associated with aircraft, 84% (n=568) were related to non-YVR aircraft operations. A summary of the 2,674 noise events is provided in the table below.

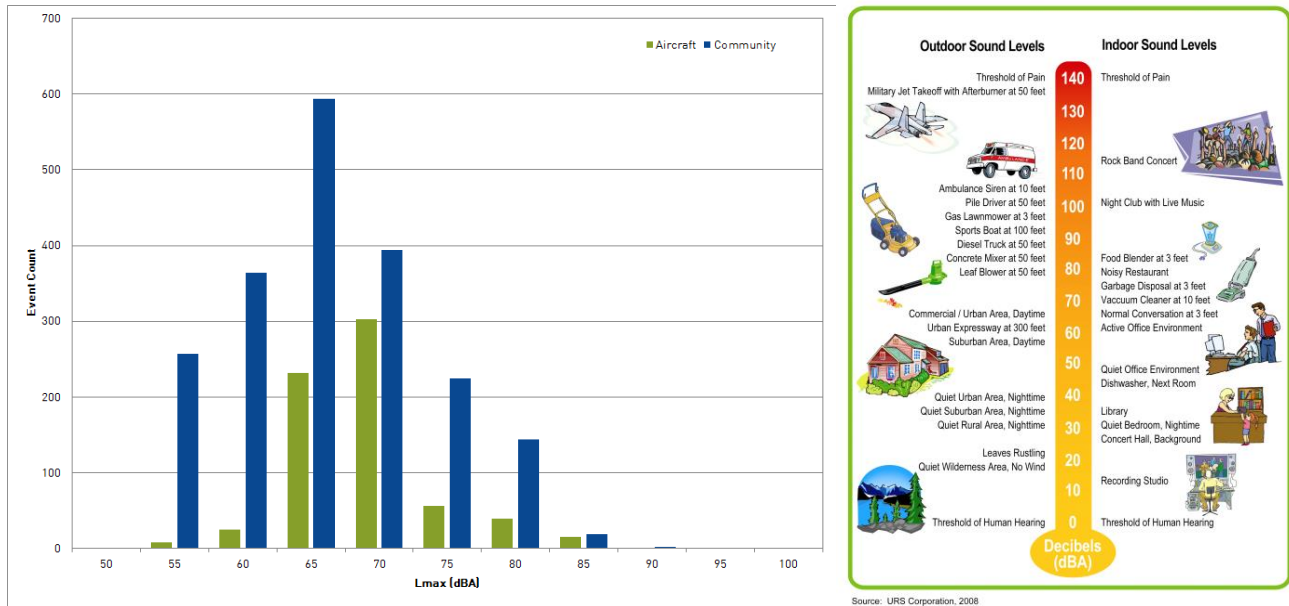
**Table 1: Noise Events at Woodland Park**

Number of Noise Events	2,674	Community Events	1998		
		Aircraft Events	676	YVR aircraft	108
				Non-YVR aircraft	568

Of the 108 YVR aircraft noise events, 60% (n=65) were related to helicopter operations, 39% (n=42) were related to arriving aircraft, and 1% (n=1) was related to a departing aircraft.

Figure 4 categorizes the 2,674 noise events according to the maximum sound level (L<sub>max</sub>) measured during the event and illustrates a comparison of typical indoor and outdoor sound levels. For example, a sound level of 70 dBA is equivalent to a vacuum cleaner at 10 feet.

Figure 4: Number of Noise Events by Lmax and Typical Indoor and Outdoor Sound Levels



### AIRCRAFT MOVEMENTS AND NOISE EVENTS

Table 2 below provides information on YVR aircraft movement data, including the number of aircraft operating within 1 km of the NMT, number of aircraft noise events, and the number of non-aircraft noise events identified during the monitoring period. Aircraft noise identified during this monitoring assessment had an average duration of 19 seconds, with the longest aircraft event lasting 120 seconds (non-YVR aircraft) and the shortest event lasting 6 seconds. Non-aircraft related noise events had an average duration of 21 seconds, with the longest event also lasting 120 seconds and the shortest event lasting 6 seconds.

Table 2: Aircraft Movement and Noise Data at the Museum of Vancouver

WEEK	Total # YVR Aircraft Operations	# Aircraft over Portable NMT location <sup>B</sup>	# of Aircraft Noise Events at NMT	# of Non-aircraft Noise Events at NMT	# of events related to YVR Aircraft	# of events related to non-YVR Aircraft
1	5,440	695	58	370	12	46
2	5,627	637	74	162	14	60
3	5,386	613	74	114	13	61
4	5,743	505	112	116	10	102
5	5,664	589	127	512	25	102
6	5,647	727	90	362	19	71
7	5,740	488	114	275	13	101
8 <sup>A</sup>	1,404	141	27	87	2	25
<b>TOTAL</b>	<b>40,651</b>	<b>4,395</b>	<b>676</b>	<b>1,998</b>	<b>108</b>	<b>568</b>

<sup>A</sup> Week 8 only involved two full days whereas the preceding weeks included a full seven days.

<sup>B</sup> This represents the number of aircraft operating within 1 km of the NMT.

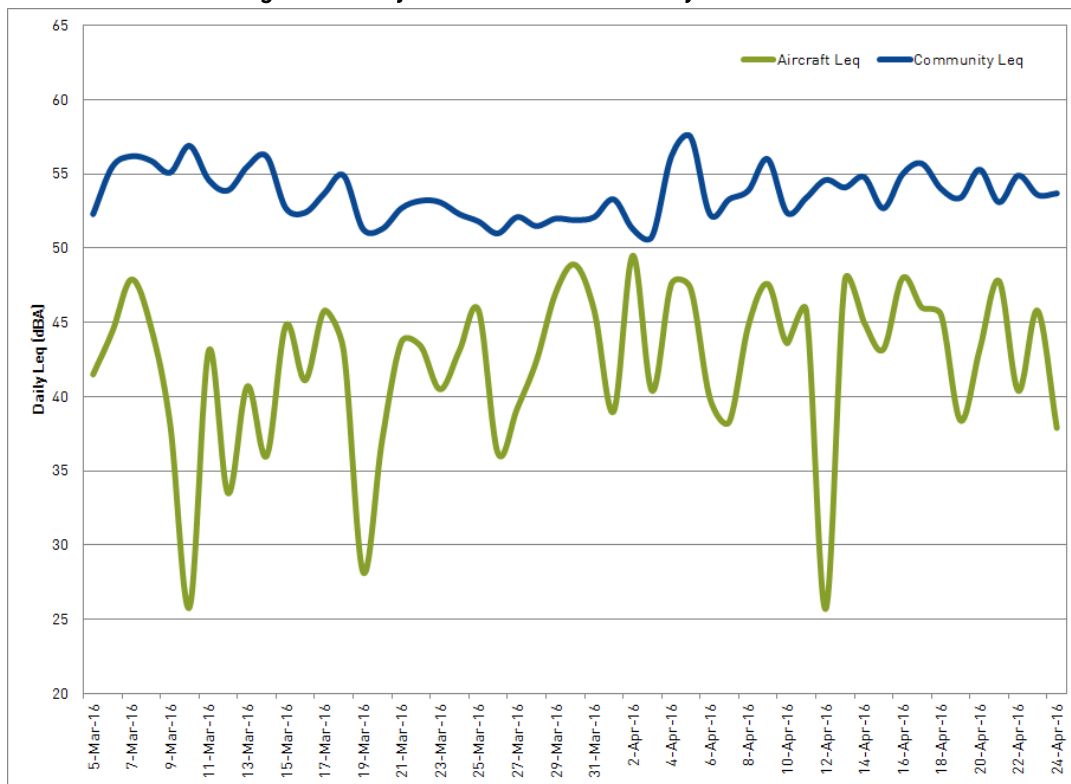
## METRICS

There are a number of different metrics that can be used to describe aircraft noise. For the purpose of this study, the Equivalent Continuous Sound Pressure Level (Leq), Exceedance Level ( $L_{10}$  and  $L_{90}$ ), and Day Night Average Sound Level (DNL) are selected as descriptors. As these properties are often difficult to understand, a basic definition is provided at the end of this report for each metric.

### 1. DAILY EQUIVALENT CONTINUOUS SOUND PRESSURE LEVEL (LEQ)

Figure 6 provides a graph of a daily Leq values, in units of dBA, for the monitoring period. The average Community<sup>2</sup> Leq at the site over the entire monitoring period was determined to be 54.0 dBA. The average Aircraft<sup>3</sup> Leq associated with the 676 aircraft events was determined to be 44.3 dBA. The difference between these two values indicates that aircraft are not a significant contributor to the overall noise environment at this location. Figure 6 illustrates daily Leq values of aircraft noise and community noise for the monitoring period.

Figure 6: Daily Aircraft and Community Noise Levels



To explain further using time as a descriptor, the total cumulative duration of the aircraft noise events was equivalent to 216 minutes out of the 51 days of monitoring. This accounts for 0.3% of the total monitoring duration. In particular, the total cumulative duration of the aircraft noise events associated with the YVR traffic was equivalent to 41 minutes out of the 51 days, or 0.06% of the total monitoring duration.

<sup>2</sup> Community noise is defined as all noise excluding that associated with aircraft.

<sup>3</sup> Aircraft noise is defined as all noise identified as aircraft. The ANOMS system is designed to identify aircraft noise events.



This does not mean that the area is not exposed to aircraft noise; however, it does indicate that other community noise sources dominate the overall noise environment. Noise events associated with aircraft, while potentially louder than many of the community noise events, constitute a small amount of exposure during a given day and other community noise source minimizes its influence.

Table 3 illustrates the contribution of aircraft noise at this location by time of day. As shown, there is a 0.4dBA difference between Community Leq and Total<sup>4</sup> Leq values for both the day and night periods. This small difference further indicates that aircraft noise within the community is not a significant contributor to the overall noise environment.

**Table 3: Averaged Hourly Noise Levels Leq (dBA)**

	Day-time (7:00AM-10:00PM)	Night-time (10:00PM-7:00AM)
Community Leq	55.5	49.1
Aircraft Leq	45.8	39.4
Total Leq	55.9	49.5

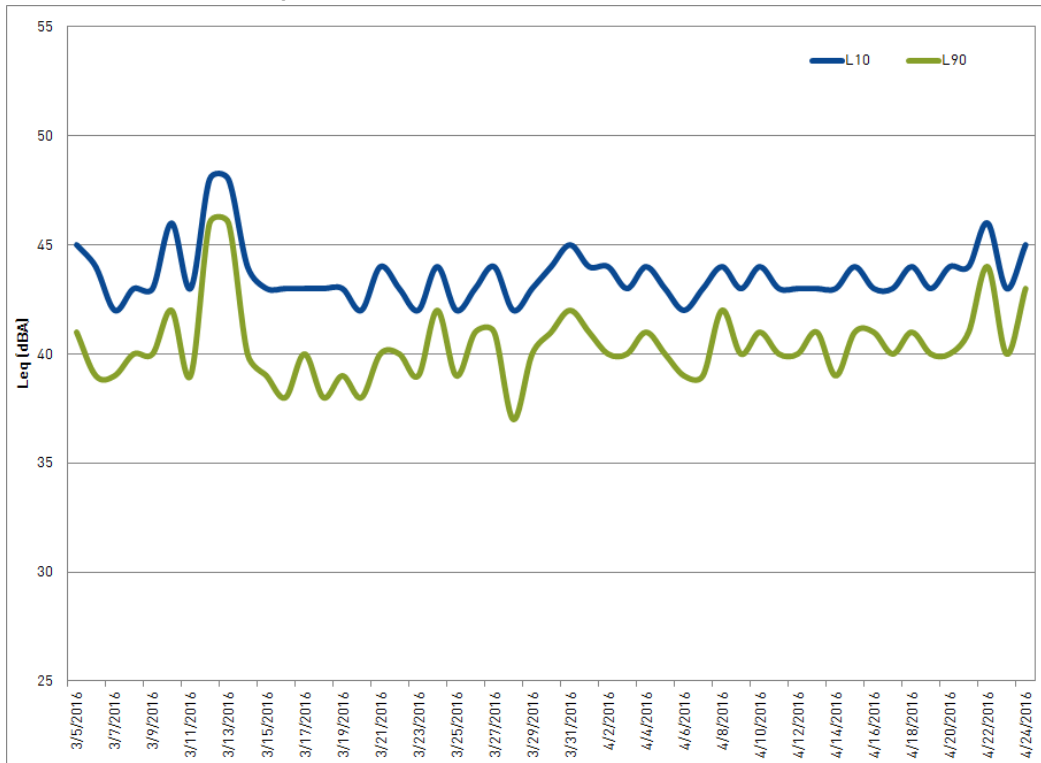
## 2. EXCEEDANCE LEVEL (L<sub>90</sub> AND L<sub>10</sub>)

Measured noise levels will vary over time, and it may be useful to quantify it in terms of the value that is exceeded for a certain percentile (N%) of total measurement time. This value is identified as L<sub>N</sub>. For example, the L<sub>90</sub> is the noise level that was exceeded 90% of the time during the monitoring period. The L<sub>90</sub> is generally referred to as the background noise levels and indicates the relative “noticeability” of all types of noise events at the site. Alternatively, the L<sub>10</sub> is the noise level that was exceeded for 10% of the time during the monitoring period. The L<sub>10</sub> does not represent the maximum sound at a location, but it generally represents the upper limits of the environmental noise at a location.

Figure 7 illustrates the daily values of the L<sub>10</sub> and L<sub>90</sub> during the monitoring period. Assessing these percentile values provides an indication of the degree in fluctuations in noise readings. As illustrated, the daily L<sub>10</sub> and L<sub>90</sub> values vary at a minimum of 2 dBA and a maximum of 5 dBA on a day-to-day basis. There is minimal to moderate fluctuations with these two values and they are often indistinguishable from one another. When L<sub>10</sub> and L<sub>90</sub> values differ between 5 and 15 dBA, it can be considered that the environment experiences a moderate fluctuation in sound. Many residential neighbourhoods fall within the range of moderate fluctuations.

<sup>4</sup> Total noise is all community and aircraft noise combined.

Figure 7: Daily Exceedance Level (L10 and L90)



### 3. DAY-NIGHT AVERAGE SOUND LEVEL (DNL)

The DNL is cumulative time weighted noise metric with each individual aircraft noise event adding to the total noise exposure. The metric was developed to predict annoyance and assist with compatible land use planning in the vicinity of airports. To calculate the DNL, the 24-hour day is divided into two parts, daytime (between 7AM and 10 PM) and night-time (10PM and 7AM). Noise events occurring at night are assigned an additional 10 dBA to account for increased annoyance to noise at night.

The measured aircraft DNL at the monitoring site was determined to be 47.5 dBA. This is significantly lower than the DNL level of 65 dBA that the US Federal Aviation Administration has set to define the threshold of significant aviation noise exposure.

## CONCLUSION

The analysis of noise data collected at the Museum of Vancouver indicates that community noise sources have greater contribution to the overall noise environment than aircraft noise in the area. During the 51-day monitoring period, aircraft noise events were small in number and duration. In particular, the number and duration of noise events related to YVR aircraft were minimal, averaging approximately 2 events a day.

The data collected during the monitoring period provides a good baseline to determine the current aircraft noise exposure in the area. This will provide a useful comparison if future measurements are to be obtained when the use of the RNP approach procedure for Runway 08L achieves a high rate of utilization.

## DEFINITIONS

### *THE DECIBEL*

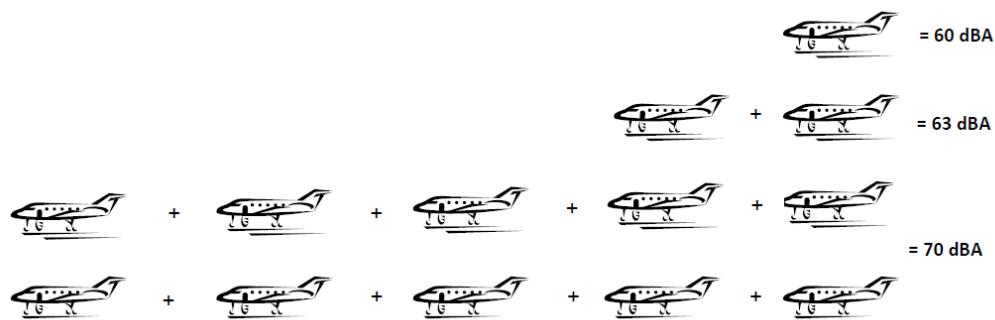
The basic unit of sound is the decibel (dB) and the normal extent of the human ear aural experience (from threshold of hearing to threshold of pain) falls within the range from 0 to 130dB. Decibels are sound pressure measurements. Sound pressure level is a measure of the sound pressure of a given noise source relative to a standard reference value. As mentioned above, dB are logarithmic quantities, relating the sound pressure level of a noise source to the reference pressure level. The reference pressure value is typical of the quietest sound that a young person with good hearing is able to detect.

Several filters have been developed that match the sensitivity of our ear and thus help us to judge the relative loudness of various sounds made up of many different frequencies. The “A” filter is the best measure for most environmental noise sources, including aircraft noise. Sound pressure levels measured through this filter are referred to as A-weighted levels, and are measured in A-weighted decibels or (dBA). For this assessment A-weighted decibels will be used for analysis.

### *LOUDNESS AND THE DECIBEL SCALE*

The human ear is capable of sensing an enormous range of sound intensities. Analogous to the familiar Richter scale of earthquake magnitude, a logarithmic scale of sound levels has been developed to compress the large range of human hearing: ranging from  $10^{-12}$  W/m<sup>2</sup> to 1 W/m<sup>2</sup> or 0dB to 120dB.

The nature of dB logarithmic scale is such that the individual sound level for different noise sources cannot be added directly to give the combined sound level of these sources. The result of the logarithmic basis for the scale is that increasing a sound intensity by a factor of 10 raises its level by 10 dB; increasing it by a factor of 100 raises its level by 20 dB; by 1,000, 30 dB and so on. When two equal noise sources radiate twice the sound energy as one noise source the human ear does not perceive the resulting noise as being twice as loud, but only recognizes it as being noticeably louder. The decibel scale functions in a similar way. For example, two small propeller aircraft each producing 70 dBA at a given distance is observed flying together at equal distances from the observer, they would produce approximately 73 dBA, not 140 dBA.



This 3 dBA increase in noise level, achieved by doubling equal noise sources, is only just perceptible by the receiver. Similarly, a 6 dBA increase in noise level would be clearly perceived, and a 10dBA increase would be perceived as being twice as loud. Thus, an aircraft that produces a noise level of 80 dBA at the receiver location would be typically judged to be twice as loud as one that produces 70 dBA at the same

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receiver location, but only half as loud as aircraft that produces 90 dBA. Most people have difficulty distinguishing the louder of two noise sources if they differ by less than 2.0 dBA.

### ***Equivalent Continuous Sound Pressure Level (Leq)***

Community noise from road, rail, aircraft and other local sources are rarely steady. Sound varies in intensity from second to second, minute to minute or hour to hour. When attempting to describe the overall noise exposure of a community over a period of time, it is necessary to average the sound level in some way. The most commonly used average noise-level descriptor is the Equivalent Sound Level (Leq). The Leq is a measure of the average exposure resulting from the accumulation of A-weighted decibel sound levels over a particular time period (e.g., 1 hour, 8 hour, 24-hour). Variations in the “average” sound level suggested by Leq are not an arithmetic value, but a logarithmic (“energy-averaged”) sound level. As a consequence, loud events will dominate sound levels measured.

### ***EXCEEDANCE LEVEL (L<sub>N</sub>)***

Human response depends directly upon the range with which noise levels vary in a given environment. For a given Leq, one would find a higher, more steady level tolerable than a lower background level with frequent noise intrusions. Exceedance levels are those noise levels that exceed for a given percentage ‘N’ of the monitoring time. L<sub>90</sub> is the noise level that was exceeded for 90% of the time whereas L<sub>10</sub> is the noise level that was exceeded 10% of the time. L<sub>90</sub> is used to estimate the residual background sound environment.

### ***Aircraft Day-Night Average Sound Level (DNL)***

The aircraft DNL is a daily average noise metric in which events occurring at night (between 10:00PM and 7:00AM) are assigned an additional 10 dBA. This night-time weighting treats one night-time noise event as equivalent to 10 day-time events of the same magnitude, and is intended to account for the greater community annoyance with night-time noise.

The US Federal Aviation Agency has guidelines for compatible land uses and environmental sound levels based on the DNL metric. These guidelines are found in the Airport Noise Compatibility Program, found in Part 150 of the Federal Aviation Regulations. The FAA has identified a DNL of 65 dBA as the threshold level of aviation noise which is deemed as significant.