

SOUND LEVEL DATA COLLECTION PROJECT IN THE VICINITY OF TORONTO WATERFRONT

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ABSTRACT

This article summarizes a three day sound level collection, or monitoring, project. The project was undertaken, in the vicinity of the Toronto waterfront, by Transport Canada Aviation (TCA) and Transport Canada Airports Group (AG) under the auspices of the Toronto Island Airport Liaison Committee (ALC). The sound level data which include aircraft and non-aircraft sound sources, were collected to provide preliminary quantitative information to the ALC for its deliberations concerning the existing acoustic climate in the vicinity of the Toronto waterfront. Both sound dosages (Leq) and single event sound levels (L_{Amax} and SEL) were measured. To maintain impartiality, no analyses have been performed nor have any conclusions been drawn. However, the results indicate that, on average, the ambient and triggered non-aircraft acoustic energies represent 80% of the total energy measured, and; the single event sound levels produced by the island airport aircraft are comparable to those produced by en-route jets and non-aircraft sound sources.

SOMMAIRE

Cet article, décrit un projet de relevé de données sonore d'une durée de trois jours sur la rive du lac Ontario avoisinant l'île de Toronto. Le projet était une collaboration de Transports Canada- Aviation (TCA) et Transports Canada Groupe des Aéroports (GA) et a été exécuté à la demande du *Toronto Island Airport Liaison Committee (ALC)*. Les émissions sonore provenant de sources aéronautiques et urbaines ont été recueillies dans le but de fournir une base de données quantitative à la ALC pour ses projets d'évaluations préliminaire du climat sonore dans cette région. Les données relevées ont servi à décrire le climat sonore en mesures de niveau de bruit continu équivalent (Leq), niveau maximum en utilisant un filtre de pondération A (L_{Amax}) et niveau d'exposition acoustique (SEL). Cet article présente les résultats du relevé mais ne présente aucune conclusion. Néanmoins, les résultats indiquent qu'en moyenne, l'énergie acoustique ambiante et de sources urbaines, représentent 80% de tout l'énergie mesuré. Les émissions sonores provenant du trafic aérien issu de l'île de Toronto se compare aux émissions sonores du trafic aérien d'aéronef turboréactés en-route et les sources urbaines.

1. INTRODUCTION

This monitoring, project was initiated by a special sub-committee of the Toronto Island Airport Liaison Committee (ALC).

The project was performed as a joint effort between Transport Canada Aviation (HQ and Ontario region) and

Transport Canada Airports Group.

It was agreed at sub-committee meetings that Transport Canada would provide the ALC with impartial sound level data for its deliberations concerning the existing noise climate in the vicinity of the Toronto waterfront. Since raw data are of limited value to the ALC, Transport Canada presented¹ the data to the ALC in a more understandable manner by sorting and plotting them. Accordingly, the

impartiality has been maintained while providing the ALC with more meaningful results.

The objectives of the project were:

1) Primarily to provide the ALC with a preliminary quantification of actual sound levels in the vicinity of the Toronto waterfront. These sound levels include those produced by aircraft using Toronto Island Airport, other aircraft e.g. en-route jets, road traffic and community sounds at three pre-selected sites.

2) Secondly to demonstrate a methodology that could be employed to garner similar data for future studies.

Based on the objectives of this project, the aircraft operations at Toronto Island Airport did not have to be necessarily representative of those that normally exist. However, apart from the unusual easterly winds causing more takeoffs over the monitoring sites than is normal, the number of aircraft operations were typical of that time of the year.

2. STUDY DESIGN

2.1 Site Locations

To enable samples of sounds existing in the vicinity of the Toronto Waterfront to be monitored, three sites were chosen from which to collect data.

The following three data collection locations were pre-selected by the ALC sub-group and inspected by the author prior to commencing monitoring.

Site 1 - located adjacent to First St. on a rough patch of ground on Ward's Island, close to the beach.

Site 2 - located between the Spadina Marina and the Queen's Quay West road, on a small picnic field in King's Landing.

Site 3 - Situated on the Pantry Athletic Field adjacent to Kew Beach Avenue, in the Beaches area during July 14 and 15 (until 1100 hours). This site was moved across the Avenue to the Beaches Park at 1200 hours on July 15 and was set up there on July 16. Site relocation was done due to high ambient levels produced by park users and City of Toronto's grass cutting machines.

2.2 Monitoring Equipment and Procedure

Each monitoring site comprised the following complement of equipment:

Site 1: Transport Canada Aviation HQ Noise Monitoring Vehicle. This is a self sufficient mobile laboratory, specially designed for noise monitoring. It contains similar equipment to that used at sites 2 and 3.

Sites 2 and 3: Bruel and Kjaer (B&K) 4435 Noise Level Analyzer
B&K 4184 Weatherproof Microphone Unit,
B&K 7618 Application Software,
Personal Computer,
Cellular Telephone,
Transceiver,
Binoculars.

Monitoring teams, consisting of two persons, were assigned to each site and all sites were co-ordinated through a central controller. Two way communication between each site and the central controller was conducted throughout the monitoring period.

Data log sheets were used to record all pertinent sound level details at each site during the monitoring periods.

Each day, all sound level data collection equipment was adjusted to the same time, thus synchronizing the sound events. The synchronization time was calibrated to the National Research Council time signal.

Each day all the acoustical instruments were calibrated before commencing monitoring to a known reference source and then checked periodically throughout each day, thus verifying the acoustical integrity of the measurement systems. These signals were recorded in the computer data bases. When calibration drift was found to occur, it was only several tenths of a decibel and was corrected immediately.

Continuous sound level measurements were taken simultaneously at the three independent sites from approximately 0630 hours to 1800 hours. However, monitoring was terminated on July 14, at approximately 1700 hours, due to rain.

Shortly after every hour, the sound level data collected were downloaded into the personal computer data bases and compared with the log sheets to ensure that the measurement systems were functioning properly.

Because the ambient levels varied among sites and sometimes throughout the day, the event recording criteria (ERC), required by the computer software, were set and adjusted accordingly. These site-specific criteria were set such that sufficient community sounds were captured but also, such that Toronto Island Airport and en-route jet

aircraft were monitored. This allowed for a variety of sounds to be monitored and subsequently compared with each other.

The ERC are required by the monitoring system to discriminate aircraft sounds from non-aircraft sounds. The ERC consist mainly of two parameters 1) the SETL and the 2) the MINIMUM DURATION. The SETL stands for Single Event Trigger Level (in dBA) and is the sound level which a sound event must exceed to be labelled as a possible aircraft event. Once the SETL has been exceeded (triggered), the sound level must remain above it for a time period equal to, or greater than, the MINIMUM DURATION for the event to be recorded as an aircraft event.

All sound level measurements were triggered using 1 second Leq on Slow detector response.

2.3 Data Presentation

The sound level data presented in the report¹ to the TCA Ontario region and ALC were "as-measured", that is, no corrections were applied to them.

The data are presented in two main ways, single event sound level descriptors i.e. L_{Amax} and SEL and, a noise dosage or equal energy descriptor i.e. Leq.

2.4 Data Legitimacy

Apart from the easterly winds causing more takeoffs over the monitoring sites than is normal, the number of aircraft operations during the monitoring period is typical of this time of year.

The data collected at sites 1 and 3 may be considered typical of the sound levels in those vicinities. However, the sound levels measured at site 2 are not necessarily typical of this general vicinity, due to the unique operational patterns of the various sound sources affecting the ambient sound levels and the complexity of building structures affecting the acoustic environment. In other words, care should be exercised in extrapolating these levels to other locations in the same vicinity.

The quantity of data collected during July 14 is limited due to the inclement weather conditions that existed. Data were collected whenever the rain subsided.

During the monitoring time periods sufficient sound events were recorded to ensure acceptable statistical accuracy for those events.

3. RESULTS

3.1 Data Treatment

Since the ERC were set to capture a selection of community sound events, the raw sound level data recorded had to be filtered at site 2. Each aircraft and non-aircraft event was then correlated with the source. Correlation of sound event with sound source was accomplished using the sound level data logs and the ATC logs.

Filtering of sound events was only necessary at site 2 due to the continual stream of road traffic and periodic en-route aircraft. When these sound events occurred at the same time, or approximately at the same time, as the Toronto Island aircraft events, the two (or three) sound events synthesized resulting in a worthless composite sound level measurement.

Additionally, some non-aircraft sound sources, e.g. trucks, motor boats etc., satisfied the ERC, consequently these events were recorded as aircraft events. This produced erroneous single event sound levels and also sound dosage levels (Leq). Only clearly identifiable events were used in the results section to ensure the highest possible integrity. For example, the dosage sound levels have been re-computed to account for the errors mentioned above.

One noticeable acoustical effect at site 2, was the reverberation of sounds off the adjacent condominium complex, located at 460 Queen's Quay.

3.2 Constraints of the Measurements

Although all the sound levels recorded are as accurate as can be expected, they are affected by certain constraints caused by the acoustic climates at the measurement sites and the objectives of the project. These constraints are described below, however, their effects are not considered to be serious.

Constraint 1.

The ERC may have affected the measured SEL and Leq results in a minor way as they were set to capture a selection of community sounds at each site and because of variation in amplitude and duration of similar pertinent events and also of the ambient levels. For example, the SETL had to be set sufficiently high so that most extraneous sound events were not recorded as events. Consequently, when an aircraft or other pertinent sound event occurred, some of the low level acoustic energy could have been missed, due to the required SETL setting.

Constraint 2.

Similarly, due to the acoustic climate, a pertinent sound event might have satisfied, and thus commenced, recording of the sound event, but the recording may have been prolonged by the fluctuating ambient levels. This phenomenon could have also occurred in the reverse order.

The effects of the first constraint mentioned above are not serious because of at least three reasons: 1) not all events were affected, 2) any low acoustic energy missed would be insignificant compared to the total acoustic energy, and 3) because the SETLs were set just above the average local ambient level, most of the acoustic energy missed would be buried in the ambient levels and would thus be inaudible.

The effects of the second constraint are caused by the project objectives and are unavoidable. Again, any additional acoustic energy added by the ambient levels to pertinent sound events would likely be insignificant if compared to the total sound event acoustic energy.

3.3 Meteorological Conditions

Weather records during the three days of monitoring show that the winds, were generally blowing from the east. This resulted in aircraft taking off from runway 08. Typically the winds blow from the west, resulting in aircraft taking off from runway 26. Accordingly, few approach or landing sound levels were recorded at the three monitoring sites. The change in wind directions caused more aircraft to overfly the three monitoring sites than would normally have happened.

Wind speeds during the three days of data collection were light, averaging approximately 5 knots. Temperatures varied between approximately 15 and 21 degrees celsius during the monitoring period. A local low pressure system on July 14, brought light intermittent rain and cooler temperatures than the other two monitoring days. Monitoring was conducted on July 14, whenever the rain subsided. The sky was generally overcast on July 14, but scattered and broken cloud was prevalent on July 15 and 16 with clear visibility.

3.4 Data Comparison

The monitoring time period varied a little among days and sites. Typically though, complete hourly measurements were taken between 0700 hours and 1700 hours.

Due to the slight variation in monitoring periods, the word "daily" has been used in the graphs to represent the appropriate Leq time period.

The data presentation is divided into two parts, 1) sound

dosages or energy averages i.e. Leq values and 2) single event sound levels i.e. L_{Amax} and SEL. Further to this, the data have been compared on an intra-site and an inter-site basis. These comparisons show the variation in average sound levels within the sites and among sites respectively.

3.5 Sound Dosage Data

These data compare the average sound levels produced by different groups of sound sources (e.g. aircraft versus cars) at a given site over a given time period.

Five groups of sound sources have been identified at site 1, these are:

T.I.A. Aircraft - those aircraft using the island airport which triggered the monitoring equipment.

Jet Aircraft - en-route aircraft (not using the island airport) which triggered the monitoring equipment.

Non Aircraft - extraneous, or ambient sounds, which triggered the monitoring equipment, e.g. motor boats, wave motion, voices etc.

Unknown sound sources - those sounds that triggered the monitoring equipment but which were unidentifiable e.g. community sounds, voices.

Ambient sound levels - all sounds which were monitored, but which did not trigger the monitoring equipment, e.g. wind noise, wave motion, distant aircraft.

At site 2, six groups of sound sources have been identified. These are the same as those at site 1, with the addition of multiple sound sources. These sounds occurred at the same time but were produced by different sources. Also, the non aircraft sounds were produced by road traffic.

At site 3, six groups of sound sources were also identified. These are the same as those at site 2, except that the non aircraft sounds were produced by road traffic, grass cutting machines, and people.

3.5.1 Leq Graphs

Graphs 1a to 1c show the variation in "daily" Leq for each sound source on a site basis.

Graphs 2a to 2c compare the "daily" Leq for each sound source at each site on a daily basis.

Graphs 3a to 3c show the distribution of acoustic energy (as percentages) for the various sound sources among the sites, on a daily basis.

Graphs 4a to 6c show the distribution of acoustic energy (as percentages) among the various sound sources at each site on a daily basis.

Graphs 3a to 6c, mentioned above, indicate the contribution of each sound source to the total Leq measured. At sites 1 and 2, it is clear that the ambient levels dominated the acoustic climate.

At site 3, the ambient and non aircraft levels dominated the acoustic climate.

The non aircraft sound sources are specific 'ambient' sounds which triggered the ERC. Therefore these two sound sources essentially belong to the same group. On average, the ambient and non aircraft acoustic energies represent approximately 80% of the total measured acoustic energy.

The contribution of the T.I.A. aircraft acoustic energy to the total measured acoustic energy (Leq), averaged over three days, at sites 1, 2 and 3 is approximately 14, 12 and 3% respectively (less than one decibel).

3.6 Single Event Sound Level Data

These data compare the sound levels produced by individual sound sources (e.g DHC-8 versus high altitude jets) during the monitoring period. To summarize the results of these comparisons, average levels are presented below.

3.6.1 LAmax and SEL Tables

Individual and average LAmax and SEL levels were compared¹ for various sound sources at sites 1, 2 and 3 respectively.

At site 1, the 3-day average levels were:

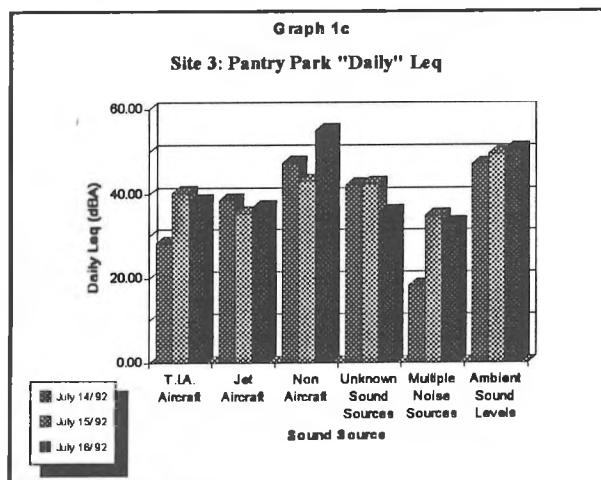
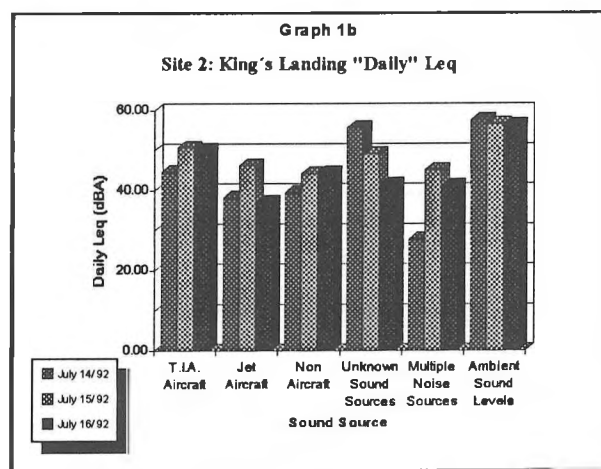
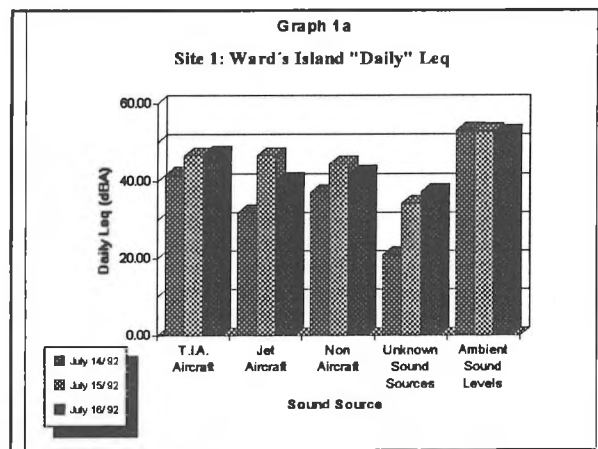
Source	SEL(dBA)	LAmax(dBA)
Jets	76.7	65.5
Gen. Av.	76.8	67.6
DHC-8	72.9	64.1
Non Ac.	75.7	67.0

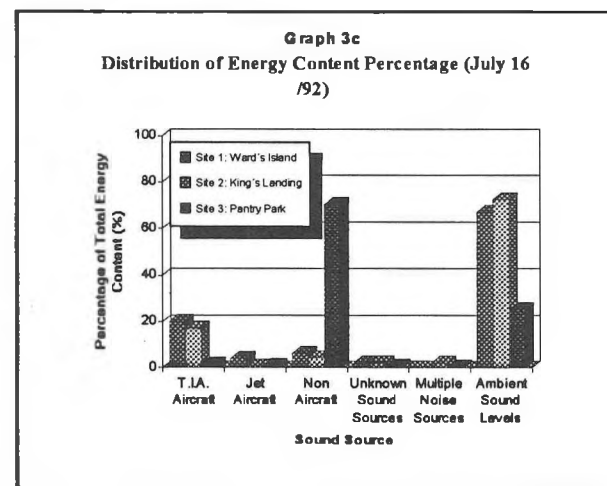
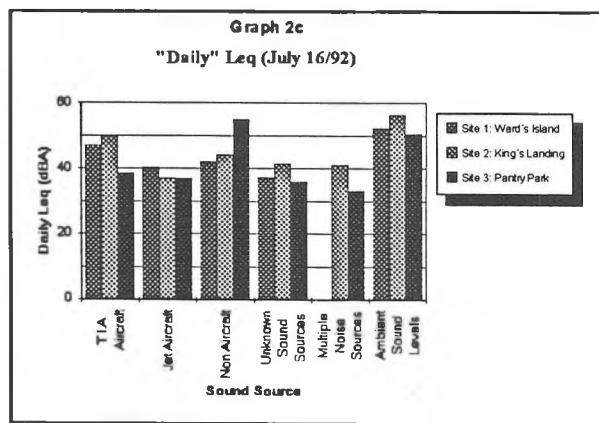
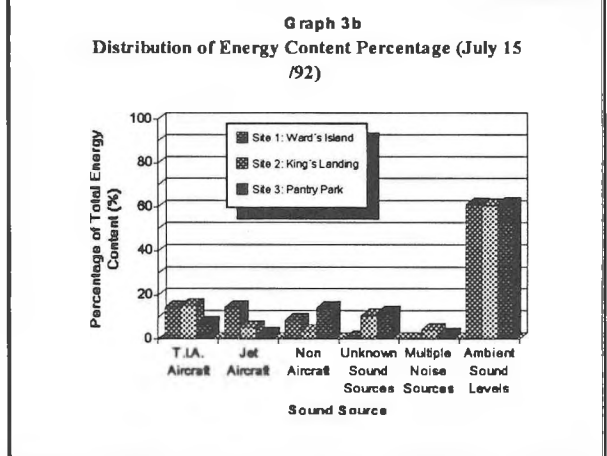
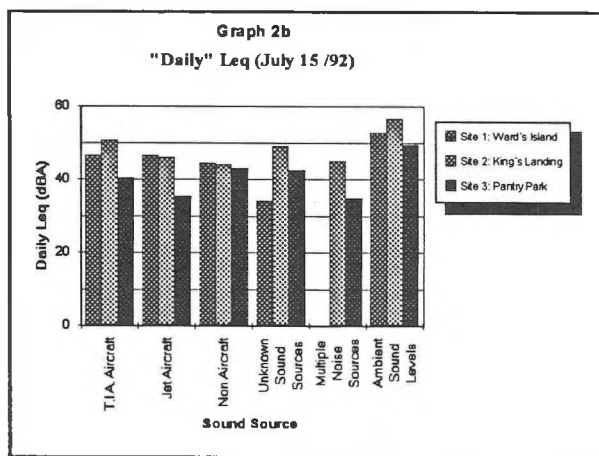
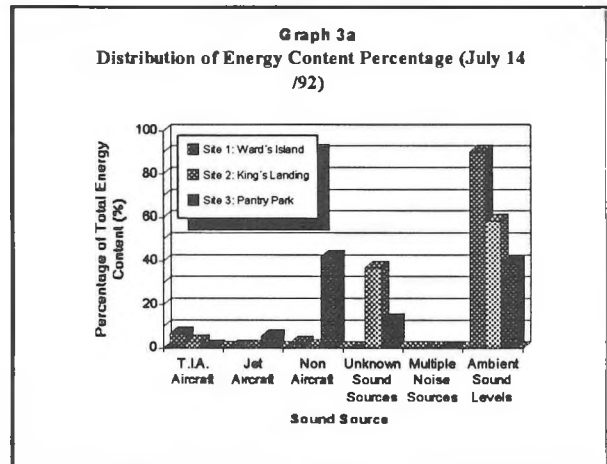
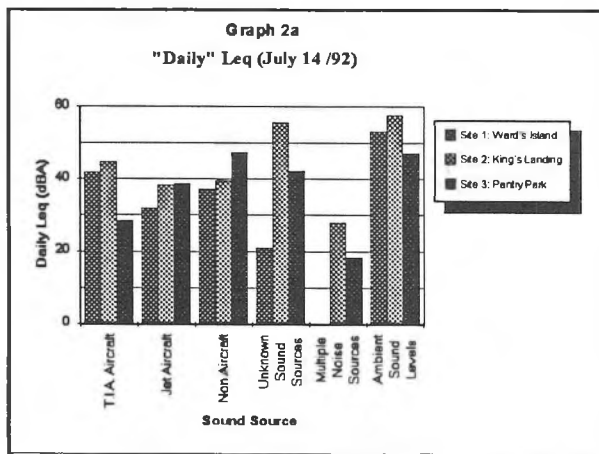
At site 2, the 3-day average levels were:

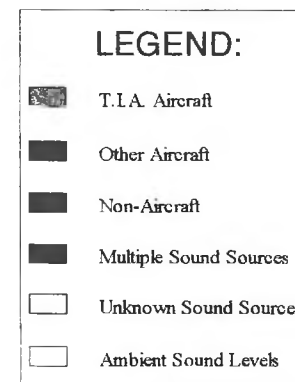
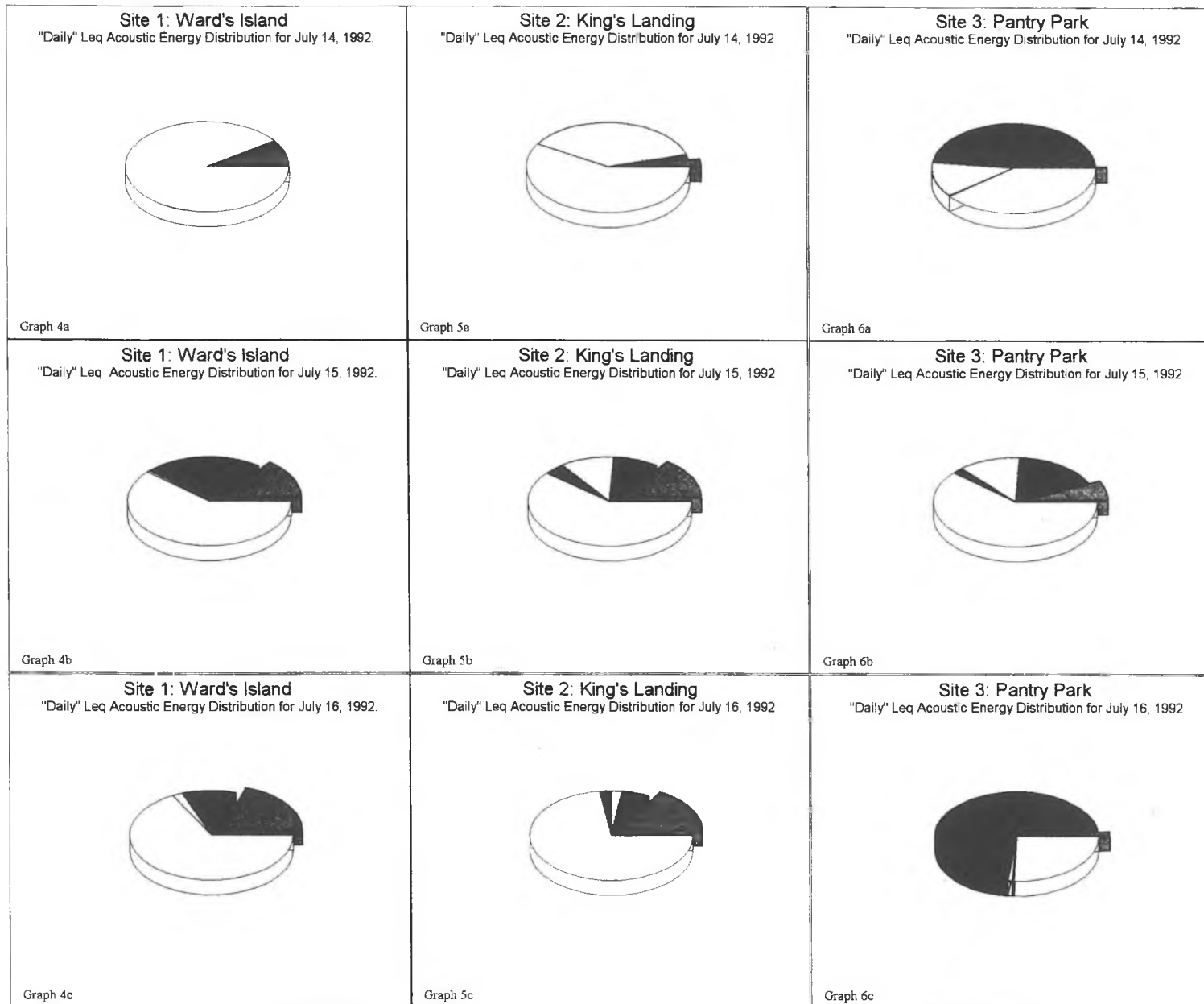
Source	SEL(dBA)	LAmax(dBA)
Jets	78.9	67.5
Gen. Av.	78.5	68.4
DHC-8	76.1	66.3
Non Ac.	75.1	67.1

At site 3, the 3-day average levels were:

Source	SEL(dBA)	LAmax(dBA)
Jets	75.0	64.4
Gen. Av.	71.8	62.4
DHC-8	72.6	62.2
Non Ac.	79.0	71.7







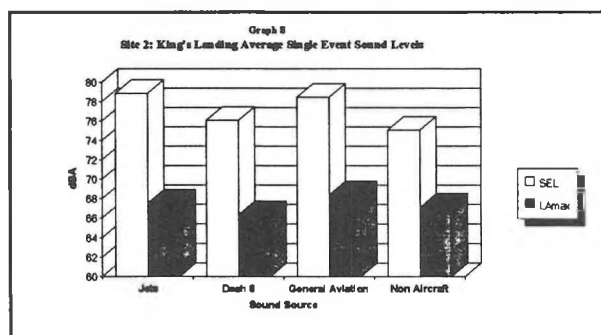
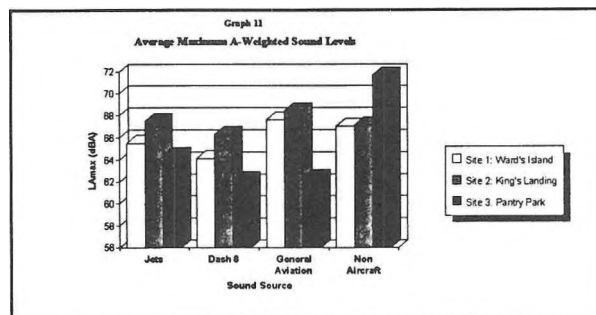
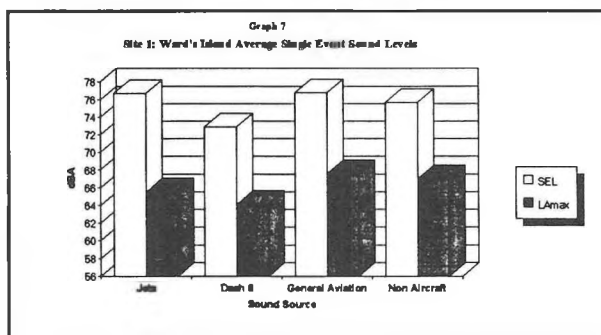
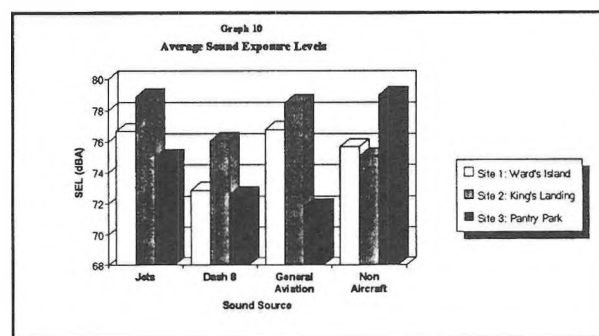
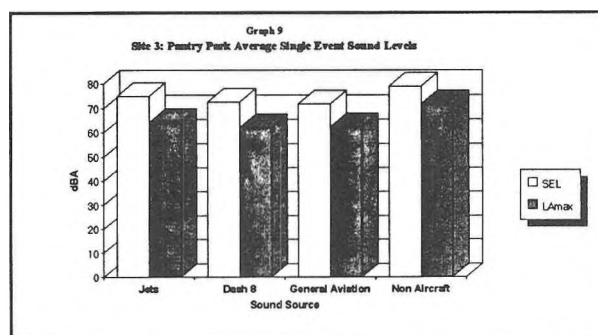
3.6.2 LAmax and SEL Graphs

Graphs 7, 8 and 9 compare the average single event sound levels within each of the three monitoring sites for the various sound sources.

These graphs show that the average sound levels produced by T.I.A. aircraft are comparable to those produced by jets and non aircraft sound sources, at sites 1 and 2. At site 3, however, the average sound levels produced by T.I.A. aircraft are slightly lower than those produced by jets and non aircraft sound sources.

Graphs 10 and 11 compare the average SEL and LAmax levels respectively, among the three monitoring sites for the various sound sources.

These graphs show that the relative significance of a sound source is dependent on the site. For example general aviation was the most significant sound source at site 1, jet aircraft and general aviation were the most significant sound sources at site 2, and non aircraft sound sources were most significant at site 3.



REFERENCES

1. Kelly, T., "Sound Level Data Collection Project in the Vicinity of the Toronto Waterfront", Transport Canada Aviation, Air Navigation System Requirements Branch, (1992).