BRIDGETOWN NOISE CHARACTERIZATION STUDY

PROJECT REPORT

Environmental Protection Department

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ENVIRONMENTAL PROTECTION DEPARTMENT

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Barbados Investment Development Corporation (BIDC)

Barbados Port Inc.

Berean Bible Church

Colonnade Mall

General Post Office

Ministry of Transport and Works
NVN Plaza

The Royal Barbados Police Force

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1 Glossary

Decibel (dB): a unit of sound level

L10: The sound level that was exceeded during 10% of the measuring time in dB(A).

L90: The sound level that was exceeded during 90% of the measuring time in dB(A).

Lcpeak: The "Peak" level is the maximum instantaneous sound pressure level measured with the 'C' frequency weighting. It is an important descriptor for an impulsive noise wave front especially with regard to the assessment of hearing hazard due to peak, impact or explosive noises.

Leq: The continuous equivalent sound level which is the single sound pressure level (SPL) that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored fluctuating sound level over the measurement period.

Lmax: The maximum sound pressure level (SPL) value measured during the duration of monitoring.

Lmin: The minimum sound pressure level (SPL) value measured during the duration of monitoring.

Sound pressure level (SPL)- A logarithmic measure of the effective sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level.

2 Executive Summary

Bridgetown is a diverse and dense urban area that a significant number of persons frequent on a daily basis. The various land uses or activities, such as residential, industrial, commercial and mass transportation terminals, coupled with the number of persons living, working, passing through and shopping there result in noise being generated.

In general, it is possible that many people are exposed to dangerous levels of noise in varying durations without realizing it, whether it is from loud music, a motorcycle, airplane or a piece of equipment. According to the World Health Organization Guidelines for Community Noise, exposure to high noise levels can lead to temporary or permanent hearing loss, increased blood pressure, increased risk for hypertension, intensification of the development of latent mental disorders and annoyance. Excessive noise levels can also cause stress related illnesses, sleep deprivation and may interrupt activities requiring concentration.

The Environmental Protection Department (EPD) designed and implemented this Bridgetown Noise Characterization Study in order to assess the sound levels which persons were exposed to while working or shopping in Bridgetown as well as to gather baseline data. In summary, the formal survey involved 24-hr sound level monitoring, collecting meteorological data, surveillance of activities and monitoring of traffic counts at or near six monitoring sites. The six monitoring locations were Barbados Port Inc (University Row), Berean Bible Church (Baxters Road), BIDC Small Business Centre (Fontabelle), General Post Office (Cheapside), Colonnade Mall (Broad Street) and NVN Plaza (Victoria Street). The noise descriptors collected during monitoring were L_{eq}, L_{max}, L_{min}, L_{10}, L_{90} on the A-scale and Lcpeak on the C-Scale.

For the six sites, the L_{eq} ranged from 55.3 to 70.2dBA, the L_{max} from 82.8 to 106.2dBA, the L_{10} from 55.5 to 74.0, and the Lc_{peak} ranged from 106.4 to 127.0dBC with the typical noise sources being traffic and people generated noise. A strong relationship existed between sound level and traffic counts as high traffic counts were found to be associated with high sound levels. The L_{eq} values recorded on Sundays were found to be statistically different to those during the week at any given site with the Sunday values being typically lower. When compared to WHO guidelines the sound levels in all the areas monitored were generally within the guideline's limits. A preliminary noise map was also created to give a visual of the sound level data collected.

3 Introduction

Environmental noise is defined as “unwanted sound” (Cowan, 1994) and can have harmful impacts on people exposed to it. In general, it is possible that many people are exposed to dangerous levels of noise without realizing it, whether from loud music, motorcycles, airplanes or everyday equipment. According to the World Health Organization Guidelines for Community Noise, exposure to high noise levels can lead to temporary or permanent hearing loss, increased blood pressure, increased risk for hypertension, intensification of the development of latent mental disorders and annoyance. Excessive noise levels can also cause stress related illnesses, sleep deprivation and may interrupt activities requiring concentration (Cowan, 1994). The risk of hearing impairment would be negligible for L_{eq}, 24hr for values up to 70dB over a lifetime (World Health Organization, 1999). To avoid hearing impairment, noise exposures should never exceed 140dB for adults and 120dB for children.

According to Barbados’ Physical Development Plan 2003 (Barbados Town and Country Development Planning Office, 2003), Bridgetown’s boundary extends from the University of the West Indies to the north along Cave Hill road, generally follows the border of the Zone 1 Water Protection Area just past the Belle Tenantry, down Two Mile Hill road and to the east side of the Garrison and Charles Fort (See Appendix 2)

Bridgetown is a diverse and dense urban area. The mixed-use area results in many land uses including residential, industrial, commercial, mass transportation terminals, educational institutions, parks/ recreational areas, fish markets, offices and government buildings within close proximity to each other. Some tourists are also attracted to Bridgetown's recent designation as a World Heritage Site as well as its rich history, which includes it being the home to one of the oldest operational parliaments in the Commonwealth.

Within the City of Bridgetown constituency there are six thousand, nine hundred and fifteen (6,915) registered voters (Barbados Electoral and Boundaries Commission, 2012) and approximately 1,300 businesses (Barbados Chamber of Commerce, 2013). Additionally it was estimated that approximately 40% of the islands transport passes through Bridgetown (Barbados Town and Country Development Planning Office, 2003). Though these values would not accurately account for persons working, passing through the city, residents below voting age or tourists, they are indicative of the fact that a number of persons could contribute to as well as be affected by the sound levels within the city.

The Environmental Protection Department (EPD) designed and implemented this Bridgetown Noise Characterization Study in order to assess the sound levels which persons were exposed to while working or shopping in Bridgetown as well as to gather baseline data. This project focused on Central Bridgetown, as delineated in Appendix 3, as this area would have the highest people counts and activity levels and should provide the highest ambient sound levels for Bridgetown as well as the highest number of persons that could be affected. A pre-survey was carried out from the 6th -13th December 2011 to gauge the noise levels as well as provide guidance for the formal survey, which was carried out from 1st June 2012 to 3rd February 2013. In summary, the pre-survey involved fifteen (15) minute samples being taken at thirteen locations while the formal survey involved 24-hour samples being taken at six locations. This document focuses primarily on the formal survey (24-hr monitoring). For further information on the pre-survey, the report entitled "Bridgetown Noise Characterization Pre-Survey Report" should be referenced.

It may be interesting to note that the Air and Noise section also conducted monitoring of the air quality in the Bridgetown area during June 2012 to May 2013; it was envisioned that this project would complement the air quality project.

4 Project Objectives & Outline

4.1 Goal

To determine the background sound levels within a specified area of Bridgetown and identify the main contributing sources.

4.2 Objectives

The objectives of the project were:

1. To obtain four, twenty-four hour samples (for three week days and a Sunday) for each of the six selected sites using the noise descriptors on the A-scale: L_{10}, L_{90}, L_{eq}, L_{max}, and on the C-Scale: L_{cpeak}.
2. To characterize the locations selected in terms of land use e.g. commercial, residential, or mixed.
3. To identify the main sources contributing to the sound levels.
4. To obtain traffic counts at the selected monitoring sites.

5. To compare the sound level results with World Health Organization standards.
6. To submit a written report on the findings of the Bridgetown Noise Characterization Study.
7. To disseminate relevant information to the applicable agencies.

4.3 Scope

The assessment focused on:

- Recording, analysing and reporting the sound levels (A-scale: L_{10}, L_{90}, L_{eq}, L_{max}, and on the C-Scale: L_{cpeak}) at the six specified sites within Central Bridgetown, as delineated in Appendix 3, during the period 1st June 2012 to 3rd February 2013.

The assessment did **not** focus on:

- Other sections of Bridgetown that are outside of the specified section or boundaries created for this project.
- Other possible noise descriptors.
- Other time periods

4.4 Research Questions

1. What were the noise descriptors (on the A-scale: L_{10}, L_{90}, L_{eq}, L_{max}, and on the C-Scale: L_{cpeak}) for the six monitoring sites?
2. What were the major sources of noise identified?
3. What was the land use of or activities carried out at the six sites?
4. How did the noise levels recorded compare with WHO guideline values for community noise?
5. Were the noise levels found during the week statistically different to those recorded on Sundays?
6. How did the pre-survey values compare to those from the formal survey?
7. Was there a correlation between the traffic counts and the noise levels recorded?

4.5 Limitations, Assumptions and Risks

The following limitations, assumptions and risks were inherent to the project:

Assumptions

- The period of monitoring produced data that was representative of typical sound levels in Bridgetown.

Limitations

- The availability of equipment during the monitoring period was a challenge because some of the equipment had to be sent overseas for annual factory calibration and this process was lengthy.
- Some activities were dependent on the timeliness of the response from stakeholders.
- The staff assigned to conduct the project had other substantive tasks and this led to time constraints due to increased workload in those areas.
- An environmental enclosure was necessary during monitoring to protect the sound level meters. Only one site could be monitored at any point in time because the team only had one enclosure.
- Any unusual, noisy events or activities occurring near the monitoring site would skew the results. In these instances, monitoring at that site was re-scheduled or cancelled. For example during the monitoring period fetes were held on Sundays at the Barbados Port Inc. As a result, Sunday monitoring was not possible at this location or any other nearby location.
- Bad weather over a weekend resulted in damage to the sound level meter. This delayed the project because the equipment had to be shipped overseas for repairs.
- Noise readings should not be taken during heavy rain or high winds above 5m/s.
- The available sound level meter did not have an auto-stop function and this resulted in the sample times being approximately 24 hours in length.
- The availability of suitable, secure locations with flat roofs was a challenge as typical Barbadian residential homes and most buildings were not built with flat roofs. As a result, 24hr monitoring within a residential area was not conducted as suitable locations were not identified.
- The availability of financial resources affected the speed at which repairs and overseas calibration could occur.

Risks

- Destructive interference by members of the general public.
- Insufficient resources to conduct all the activities of the project.

4.6 Overview of Noise

Some of the typical noise sources within Bridgetown were traffic and people generated noise. Below is a general description of the typical noise sources within towns and the impact they could have on sound levels.

Traffic Noise

Traffic noise is a combination of the noises produced by vehicle engines, exhaust, and the interaction of the moving vehicles' tyres with the road. The level of traffic noise depends on various factors (Washington State Department of Transportation) such as:

- **Traffic volumes** - Roads with more vehicles are generally louder.
- **Traffic speeds** - Traffic is louder at higher speeds.
- **The percent of heavy trucks on the road** - Larger vehicles are generally louder.
- The **terrain** - A steep incline causes heavy labouring of vehicle engines, which increases traffic noise levels.

Other factors, which affect the traffic noise were: the condition of vehicles e.g. if there are any defective mufflers; vegetation; the use of horns or alarms; the car radio's volume and any natural or manmade obstacles.

People Generated Noise

People are also sources of sound; simple activities such as walking and talking may generate noise. In addition, within towns there are often persons soliciting customers loudly, sometimes with loud speakers, to buy their wares. Recreational activities such as children playing games, adults playing dominoes or friendly heated discussions occur within the city and also contribute to noise levels.

Other Sources

Other sources of noise within Bridgetown include amplified music from bars or businesses, humming air conditioning units and in some areas, animal noises e.g. dogs barking or birds chirping.

Noise Level Measurement

Noise is measured in decibels (dB); the zero on a decibel scale is at the threshold of hearing, the lowest sound pressure that can be heard by a person with healthy hearing (Cowan, 1994). Some typical sound levels of common sources are about 30dB for a whisper, about 60dB for typical conversation and about 130dB for a jackhammer (American Speech-Language-Hearing Association (ASHA)).

Noise is measured using different frequency weightings (e.g. A or C scale) or time weightings (e.g. fast, impact, slow). The 'A' frequency weighting is based on human hearing sensitivity to sound pressure levels below 70dB. Especially for sound pressure levels greater than 90dB, human frequency sensitivities level off at lower frequencies such that the C-weighting may be more appropriate to quantify human sound perception. Most agencies and rating methods however use A-weighting exclusively for noise assessment, independent of the sound pressure level, for ease of data taking and consistency of results (Cowan, 1994). As a result, the 'A' frequency weighting was selected for monitoring. The noise descriptors collected during monitoring were L_{eq}, L_{max}, L_{min}, L_{10}, L_{90} and L_{cpeak}.

Noise Level Standards Laws and Legal Policies

As of July 2014, there were no Barbadian national laws or standards, which specifically addressed noise pollution. However, the Environmental Protection Department (EPD) had prepared a Noise Abatement and Discussion Concepts Paper that was accepted by Parliament in 2007. The policy indicated that World Health Organization Guidelines on Community Noise should be used in assessing noise levels/complaints. In the absence of national laws or standards this accepted national policy is referred to when assessing noise levels.

5 Study Area

The six monitoring locations were Barbados Port Inc (University Row), Berean Bible Church (Baxters Road), BIDC Small Business Centre (Fontabelle), General Post Office (Cheapside), Colonnade Mall (Broad Street) and NVN Plaza (Victoria Street). The list of the contact persons and contact information for the sites is shown in Appendix 8. The description and pictures of the monitoring locations are provided below:

Barbados Port Inc (University Row/Prescod Boulevard):

Barbados Port Inc. (BPI) was located approximately 45 metres from Prescod Boulevard, a road which was heavily used during the day, and approximately 70 meters from a roundabout. The GPS coordinates were 13° 6'18.30"N, 59°37'33.55"W. The area was industrial/ commercial with businesses or other entities nearby such as BICO, Rainbow Paper Products, the Bridgetown Port (sea port) where many trailers passed during the day, a marina where boats were repaired/ serviced and various offices. Prescod Boulevard was also part of the route used by the following buses: Rock Hall, Rock Dundo, St. Andrew's Church, Shorey Village, Chalky Mount and was one of the main roads used to enter or leave Bridgetown. This location was monitored on the 25th, 26th and 27th of June, 2012. Monitoring on Sunday was not possible as fetes were held at that location every Sunday during the monitoring period.

The BPI building was an office where mostly paperwork or policy administration with respect to cargo or persons entering Barbados via sea was conducted. The roof of the building was flat, 25ft above the ground and access was available via a ladder. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 1).

Figure 1: Barbados Port Inc (BPI)

Berean Bible Church (Baxters Road):

Berean Bible Church was located about 25 metres from a traffic lights intersection. The GPS coordinates were 13° 6'15.64"N, 59°37'1.90"W. The area was primarily commercial and the adjacent road was on many bus routes and was used often by heavy vehicles and trailers. Businesses in the area included small bakeries, food stalls/restaurants, a pavilion and pasture for sporting activities, supermarkets and bars. Nightlife included selling at food stalls and music. This site was monitored on the 13th, 14th, 16th and 17th of January 2013. Monitoring was conducted from an elevated roof deck/patio. The roof deck

was 14ft 9 inches above the ground and accessible via a first floor window. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 2)

Figure 2: Berean Bible Church

<u>BIDC Small Business Centre (Fontabelle):</u>

The building was located approximately 40 metres from a road which was heavily used. The GPS coordinates were 13° 6'4.06"N, 59°37'25.58"W. The area was commercial with businesses such the Nation newspaper, the Advocate newspaper, First Caribbean International Bank and Brankers (a home accessory retail business). The site was monitored on the 28th, 29th, 30th and 31st of January 2013 and on the 3rd of February 2013.

BIDC Small Business Centre was an office where small businesses were facilitated or received assistance. The roof of the building had three levels. The highest part of the roof was used for the monitoring activity. It was 25ft 2.5 inches above the ground and was accessible via a ladder. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 3)

.

Figure 3: BIDC Small Business Centre

General Post Office (Cheapside)

The General Post Office (GPO) was located approximately 10 metres from the Cheapside Market, along Cheapside road. The GPS coordinates were 13° 5'53.84"N, 59°37'15.55"W. It was also adjacent to two bus terminals (one for government owned buses and another for privately owned buses). The area was primarily commercial with businesses/entities nearby such as a stationer, a market with stalls/booths, and other shops.

This location was monitored on the 3rd, 4th, 5th and 6th of June 2012. The GPO was an office building where mail was processed and other postal related activities occurred. The building had several roofs and the one chosen was flat, 32ft 7inches above the ground and accessible via a spiral staircase. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 4)**Error! Reference source not found.**.

Figure 4: General Post Office

Colonnade Mall (Broad Street)

The Colonnade Mall was located on Broad Street, in the heart of Bridgetown. The GPS coordinates were 13° 5'51.24"N, 59°36'58.51"W. The area was commercial with many retail stores in the immediate vicinity.

This location was monitored on the 17th, 19th, 20th and 21st of June 2012. The Colonnade Mall was a three storey mall where there were various retail stores e.g. clothing, jewellery, a supermarket and a food court on the first two floors and office spaces on the third floor. The roof of the building had flat areas, was 32ft 10inches above the ground and accessible via an elevator. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 5)**Error! Reference source not found.**.

Figure 5: Colonnade Mall

NVN Plaza (Victoria Street)

NVN Plaza (NVN) was located between two parallel roads (High Street and Middle Street). The GPS coordinates were 13° 5'51.94"N, 59°36'53.44"W. The sound level meter was set up on the side of the roof closest to Middle Street. The area was commercial with various retail shops, a car park nearby and mostly pedestrian activity.

This location was monitored on the 1st, 2nd, 3rd, 4th and 5th of July 2012. NVN is a two-storey mall with various retail stores on the ground floor and at the time of monitoring there was an unoccupied space on the first floor. The roof of the building was flat, 21ft 10 inches above the ground and accessible via

stairs. Pictures of the building as well as the monitoring equipment on the roof of the building are shown in (Figure 6)**Error! Reference source not found.**.

Figure 6: NVN Plaza

6 Methodology

The survey methodology was based primarily on the following documents:

i. ISO 1996/1-1982 Acoustics - Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures;
ii. ISO 1996-2: 1987 Acoustics – Description and measurement of environmental noise – Part 2: Acquisition of data pertinent to land use and;
iii. ISO 1996-3: 1987 Acoustics – Description and measurement of environmental noise -- Part 3: Application to noise limits.

In summary, the formal survey involved 24-hr sound level monitoring, collecting meteorological data, surveillance of activities and monitoring of traffic counts at or near the six sites.

Based on the information from the pre-survey, six sites were selected for further monitoring using the following criteria:

1. Representation of different zones: It was desired to have at least one of each type of zone represented (e.g. central Bridgetown, residential, commercial, heavily trafficked areas, high pedestrian count areas).
2. Expected degree of stakeholder interest: Noise levels in some areas such as Broad Street and Swan Street are anticipated to be of interest to stakeholders.

3. Based on the equivalent sound levels (L_{eqs}) measured during the pre-survey sites were selected such that no two areas had similar L_{eqs} and activities.
4. The identification of potential suitable locations for formal monitoring taking into account factors such as security, accessibility, roof type and roof height.
5. The expected change in activity during the day: Some areas such as Baxter's Road were known for their active nightlife especially on weekends.

The six sites chosen and monitored in the formal study were Barbados Port Inc. (University Row), Berean Bible Church (Baxters Road), BIDC Small Business Centre (Fontabelle), General Post Office (Cheapside), Colonnade Mall (Broad Street) and NVN Plaza (Victoria Street). The Google Earth aerial map in Figure 7**Error! Reference source not found.** shows the six sites used in the formal survey. At each of the sites the sound level meter was set up on a roof for at least three (3) 24-hour periods.

The monitoring techniques employed during monitoring were:

1. The microphone was positioned 3m-11m above the ground and 1.2m-1.5m above the roof level. The microphone was also placed at least 3.5m away from any reflecting structure other than the ground.
2. A windscreen was used during monitoring.
3. It was preferred that the wind speed was between 1 and 5m/s, measured at a height of 3m to 11m above the ground.
4. Samples were taken when there was no heavy precipitation.
5. In-field calibration was done prior to and after taking any readings.

Four (4) twenty-four hour samples (on three weekdays and one Sunday) were taken for each of the six selected sites. Weekdays were chosen to determine the noise levels that persons would be exposed to while working or shopping, while Sundays would give an idea of the sound levels during low activity and be indicative of the noise levels on bank holidays. It should be noted that the schedule of events to be held at the Kensington Oval was also obtained so that crop over events did not clash with the monitoring days.

The noise descriptors collected were on the A-scale, fast response: L_{10}, L_{90}, L_{eq}, L_{max}, and on the C-Scale: L_{cpeak}. The range used during monitoring was 30-110dB or 40-120dB as appropriate and the meter was

set to log every ten (10) seconds. The logged data was downloaded from the sound level meter to a laptop. An external power supply (6V 10Ah) was used as the primary power supply, however AA batteries were also placed in the monitor as a backup and to facilitate changing of the external batteries if necessary. The portable noise monitoring option –Type 3571 was used as this is an enclosure designed to facilitate outdoor monitoring over long periods. It protected the sound level meter from rain and other elements of the weather.

Surveillance of the activities occurring at each site was done from 10th April 2012 to 25th May 2013 in order to identify the potential sources of noise. Staff of the Environmental Protection Department visited each site forty-two randomly selected times to observe the activities, which typically occurred at each of the sites. Each day of the week was assessed during the day and at night in triplicate resulting in twenty-one (21) day time (6 am to 6pm) observation times and twenty-one (21) night time observation times (6pm to 6am) for each site.

The meteorological data was obtained using the Kestrel 4000, a portable weather meter. The Kestrel was set up next to the sound level meter during monitoring. The meteorological data collected were temperature, wind direction, wind speed, relative humidity, barometric pressure and cloud cover. Other data collected during the project included the type of instrumentation used, start and stop times, GPS location, description of any source(s) of noise and the type of area or zone. The survey form used to record the data is shown in Appendix 1.

At EPD's request, the Ministry of Public Works and Transport placed traffic counters on the roads near to the monitoring sites. The schedule outlining when the traffic counters were deployed at the various locations is shown in Appendix 4. Where possible the traffic data was collected while sound level monitoring occurred. However, this was not always possible due to various reasons such as the malfunction of the counters.

The collected data was analyzed and a preliminary noise map was created. The software packages used were Minitab 15 Statistical Software, SPSS Statistics and Microsoft Excel. The aerial maps were produced using Google Earth. The colour scheme used was the same as that identified in ISO 1996-2 section 7.

Figure 7: Map of Bridgetown showing the locations for the formal survey

7 Results and Discussion

7.1 Meteorological data

Localized meteorological data was collected using the Kestrel weather monitor. This was in accordance with ISO-1996, which required that wind speed, temperature, relative humidity and atmospheric pressure be recorded during monitoring. The standard indicated that the wind speed should be between 1-5 m/s during monitoring. For all sites, the average wind speed fell within the 0.8-1.9 m/s range and the maximum wind speed varied from 1.7-11.9 m/s. As wind speed cannot be controlled a windscreen was used during monitoring to reduce the effect on the sound level due to the wind. The standard also indicated that there should be no heavy rainfall during monitoring. This was assessed informally by using national weather reports as well as assessing the dampness of the surrounding areas at the site. It is agreed that a more rigorous method of determining the amount of rainfall (e.g. using a rain gauge) would be better for future projects. It should be noted that cloud cover was only recorded once per day (early morning). The meteorological conditions recorded are tabulated below for each site.

Table 1: Meteorological data collected at the General Post Office

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
3rd June 2012	Max: 6.3 Avg:0.8	Range: 43.5-85.3 Average: 67.9	Range: 24-33.5 Average: 24	Range: 1014-1018.1 Average: 1013.1	6/8
4th June 2012	Max: 6.7 Avg:0.9	Range: 43.9-80.7 Average: 64.7	Range: 25.3-32.8 Average: 28.1	Range: 1013.6-1016.6 Average: 1015.0	2/8
5th June 2012	Max: 9.2 Avg: 1.7	Range: 51.0-85.7 Average: 74.6	Range: 26.4-32.1 Average: 28.2	Range: 1014.3-1017.0 Average: 1015.5	5/8
6th June 2012	Max 1.7 Avg 0.8	Range: 51.4-79.1 Average: 68.3	Range: 26.9-32.3 Average: 28.8	Range: 1014.8-1016.1 Average: 1017.3	6/8

Table 2: Meteorological data collected at the Colonnade Mall

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
17th June 2012	Max: 7.8 Avg:1.6	Range: 45.6-86.2 Average: 69.5	Range: 25.5-34.9 Average: 29	Range: 1012.9-1015.1 Average: 1016.7	2/8
19th June 2012	Max: 9.1 Avg: 1.8	Range: 40.2-91.5 Average: 66.8	Range: 25.4-35.0 Average: 29.1	Range: 1014.3-1017.3 Average: 1015.8	5/8
20th June 2012	Max: 7.9 Avg: 1.9	Range: 46.5-84.0 Average: 70.2	Range: 26.3-34.7 Average: 29.4	Range: 1013.6-1016.4 Average: 1014.9	3/8
21st June 2012	Max: 8.0 Avg: 1.6	Range: 43.5-85.4 Average: 66.4	Range: 25.0-35.2 Average: 29.0	Range: 1013.3-1016.1 Average: 1014.9	1/8

Table 3: Meteorological data collected at the Barbados Port Inc (BPI)

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
26h June 2012	Max: 11.9 Avg:1.9	Range: 50.9-82.0 Average: 68.9	Range: 26.5-32.5 Average: 28.9	Range: 1015.0-1018.3 Average: 1016.7	2/8
27th June 2012	Max: 11.7 Avg: 1.7	Range: 45.5-92.3 Average: 67.6	Range: 25.1-33.8 Average: 28.9	Range: 1016.3-1018.5 Average: 1017.4	3/8

Table 4: Meteorological data collected at NVN Plaza

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
1st July 2012	Max: 6.3 Avg:1.1	Range:39.1-98.0 Average: 63.6	Range: 23.3-36.7 Average: 28.2	Range: 1012.8-1019.2 Average: 1015.1	4/8
2nd July 2012	Max: 6.7 Avg: 0.9	Range: 44.7-82.3 Average: 66.1	Range: 25.9-34.6 Average: 29.5	Range: 1012.9-1015.9 Average: 1014.6	5/8
3rd July 2012	Max: 6.2 Avg: 0.9	Range:48.2-97.1 Average: 77.8	Range: 24.0-35.5 Average: 27.9	Range: 1011.9-1014.3 Average: 1013.3	overcast
4th July 2012	Max: 4.8 Avg: 1.0	Range: 54.0-93.7 Average: 78.1	Range: 25.2-33.4 Average: 27.9	Range: 1012.5-1015.6 Average: 1013.8	
5th July 20129	Max: 6.7 Avg: 1.2	Range: 47.8-79.0 Average: 65.9	Range: 26.2-34.7 Average: 29.5	Range: 1011.9-1014.71 Average: 1013.5	

Table 5: Meteorological data collected at Berean Bible Church

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
13th Jan 2013	Max: 3.7 Avg:0.1	Range:25.4-89.9 Average: 61.2	Range: 20.7-44.9 Average: 26.6	Range: 1011.4-1015.7 Average: 1013.5	clear
14th Jan 2013	Max: 4.2 Avg: 0.2	Range: 36.5-84.4 Average: 62.6	Range: 20.1-35.9 Average: 26.3	Range: 1013.6-1016.7 Average: 1015.0	clear
16th Jan 2013	Max: 5.6 Avg: 0.2	Range:34.7-81.5 Average: 61.2	Range: 20.3-36.6 Average: 27.2	Range: 1012.8-1016.3 Average: 1014.6	clear
17th Jan 2013	Max: 3.6 Avg: 0.2	Range: 31.2-88.4 Average: 61.7	Range: 21.4-36.9 Average: 27.6	Range: 1013.5-1017.8 Average: 1015.5	clear

Table 6: Meteorological data collected at the BIDC Small Business Centre

Date (start)	Wind Speed (m/s)	Relative humidity (%)	Temperature (degC)	Atmospheric Pressure (mbar)	Cloud Cover
28th Jan 2013	Not recorded	Range:43.7-96.3 Average: 73.3	Range: 22.3-33.3 Average: 26.1	Range: 1014.7-1018.4 Average: 1016.4	7/8
29h Jan 2013	Max: 8.6 Avg: 1.9	Range: 44.2-76.4 Average: 65.4	Range: 24.8-33.6 Average: 27.1	Range: 1015.2-1016.3 Average: 1019.0	1/8
30th Jan 2013	Max: 6.7 Avg: 1.0	Range:46.7-93.8 Average: 68.6	Range: 22.3-32.4 Average:26.5	Range: 1014.0-1015.6 Average: 1017.4	3/8
31st Jan 2013	Max: 9.2 Avg: 1.7	Range: 47.3-70.7 Average: 91.4	Range: 22.0-32.3 Average: 26.3	Range: 1013.7-1015.4 Average: 1017.5	1/8
3rd Feb 2013	Max: 9.8 Avg: 1.1	Range: 37.0-97.6 Average: 66.2	Range: 21.7-33.9 Average: 25.8	Range: 1012.4-1014.5 Average: 1016.7	overcast

7.2 What are the noise descriptors for the six monitoring sites?

For the six sites the L_{eq} ranged from 55.3 to 70.2dBA, the L_{max} from 82.8 to 106.2dBA, the L_{10} from 55.5 to 74.0, the L_{90} ranged from 46.0 to 59.9 dBA and the L_{cpeak} ranged from 106.4 to 127.0dBC.

The tables below summarized the decibel readings obtained during monitoring at each site. The raw data can be found in Appendix 5.

Table 7: Noise descriptor results

L_{eq}

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	60.3-70.2	62.1-63.0	60.2-62.4	58.6-63.4	60.5-61.2	58.5-63.4
Sunday Value	58.5	60.9	*	55.3	61.9	60.5

L_{10}

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	62.5-74.0	64.5-64.5	63.0-65.5	61.5-65.5	63.7-64.3	60.6- 62.8
Sunday Value	61.0	62.5	*	55.5	64.1	61.3

* Sunday monitoring at this location was not possible as fetes were held at this location on Sundays during the monitoring period.

L_{90}

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	46.0-54.5	50.0-52.0	50.5-51.5	50.5-51.0	51.5-52.3	54.8-59.9
Sunday Value	48.5	50.5	*	50.5	52.1	59.5

Lmin

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	41.9-43.2	48.4-48.6	47.6-49.2	43.9-44.5	36.4-38.3	49.7-51.3
Sunday Value	53.5	[§]	*	44.9	37.9	50.4

L_{max}

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	87.3-90.6	87.8-95.4	88.4-93.5	83.2-86.8	93.3-94.1	82.8-106.2
Sunday Value	89.1	92.6	*	83.1	92.7	84.6

L_{cpeak}

	General Post Office	Colonnade Mall	Barbados Port Inc.	NVN Plaza	Berean Bible Church	BIDC Small Business Centre
Weekday Range	112.0-112.8	106.4-108.2	113.0-116.5	108.9-118.1	115.2-116.5	111.2-127.0
Sunday Value	108.7	121.1	*	111.7	110.2	109.1

In general, for any particular site, the 24hr L_{eq} measurements varied by approximately 1 to 5dBA. For example the Colonnade Mall's L_{eq} varied from 62.1 to 63.0dBA for the three weekdays monitored and the BIDC Small Business Centre from 58.5-63.4dBA. The exception was the GPO where a difference of approximately 10dBA was noted between the lowest and highest L_{eq} for the three weekdays monitored. Similarly, for most sites the weekday 24hr L_{10} measurements varied by 1-5dBA except for the GPO, which showed a difference of approximately 12dBA. The weekday L_{90} 24hr measurements also exhibited differences of 1-5dBA except at the GPO where the difference was 8.5dBA. The weekday 24hr L_{min}, L_{max} and L_{cpeak} measurements varied by approximately 0.2-3dBA, 0.8-23.4dBA and 0.8-15.8dBA respectively for all sites including GPO.

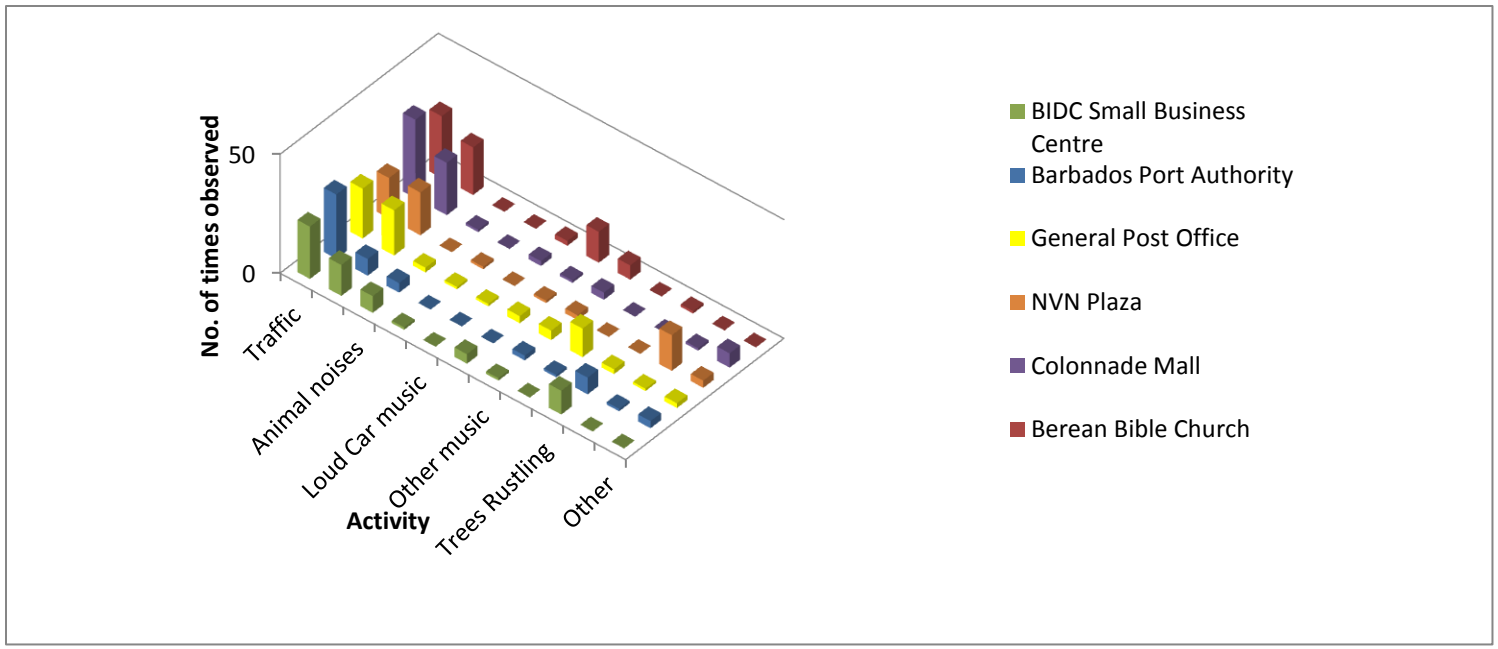
[§] The minimum sound level was lower than the range that the meter was set at.

It was noted that one day of monitoring, 6th June 2012, was the reason for the anomalies in the noise descriptors (L_{eq}, L_{10},L_{90}) observed at the GPO. It is possible that on 6th June 2012 an extraneous activity or sound, which was not normal, caused the variance. Given the anomaly, this day was removed from further analysis. The remaining two week days monitored at GPO showed consistency in the results as a difference of 1 to 3dBA was noted between the noise descriptors taken over 24hrs (L_{eq}, L_{10},L_{90}). The L_{min}, L_{max} and L_{cpeak} are all instantaneous values that would not be very sensitive to changes in the sound level patterns over the entire monitoring period at any site. While important to record these values, they would not necessarily reflect any anomalous trends over the monitoring period at GPO site as they are instantaneous measurements.

7.3 What were the major sources of noise identified?

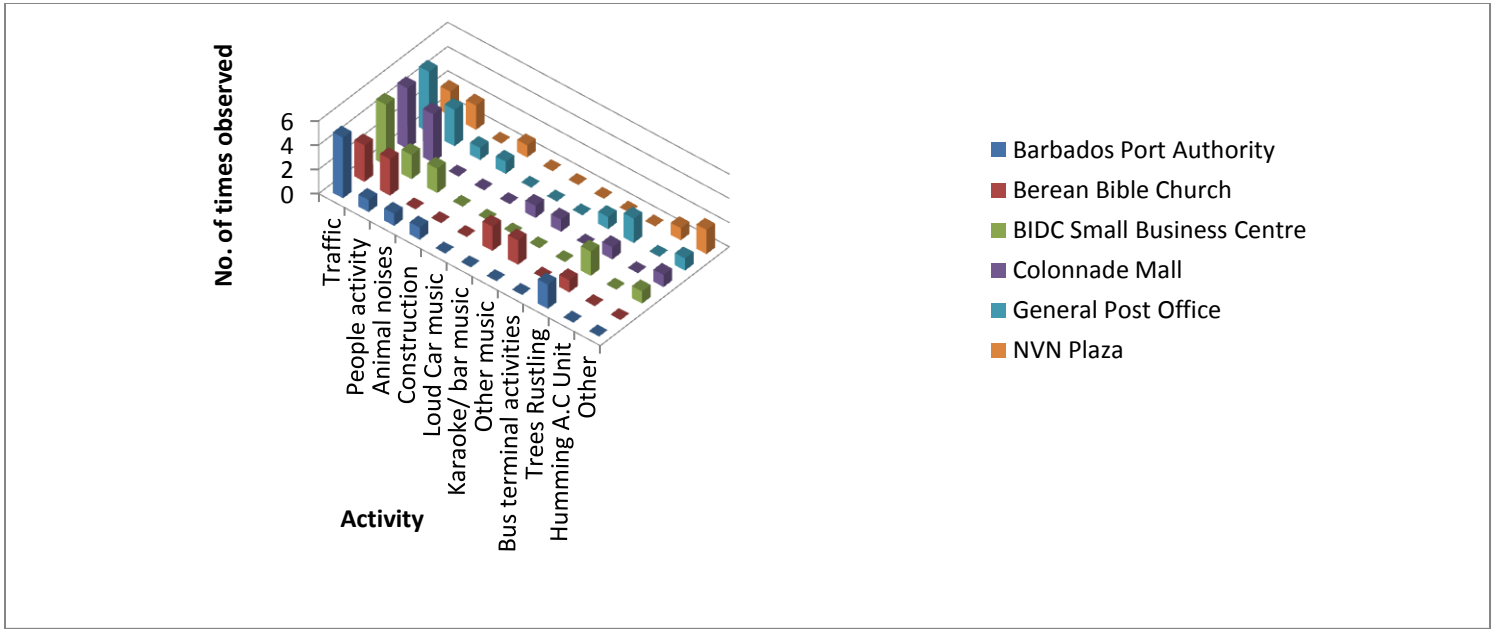
Traffic and people related activities were the most frequent sources of noise identified.

The tables and figures below shows the number of times each location was surveyed, the types of activities observed as well as the frequency with which they were observed. The sources of noise observed included traffic, people related activities such as talking or playing, animal noises, construction, music and bus terminal activities. As expected, the most frequent sources of noise observed were traffic and people related noises such as talking and liming/recreational activities. For example, the top three sources of noise observed at the General Post Office were traffic, people related activities and bus terminal activities. Sources that were observed infrequently or at relatively few sites were placed in the “Other” category for example church bells, clock chimes, boat repairs or landscaping with motorized equipment. The observed activities are displayed in the tables and bar charts below.



Location	Total number of times observed	Traffic	People activity	Animal noises	Construction	Loud Car music	Karaoke/ bar music	Other music	Bus terminal activities	Trees Rustling	Humming A.C Unit	Other
Barbados Port Authority	36	27	7	4	0	0	0	2	1	7	1	3
Berean Bible Church	36	26	20	0	0	2	13	6	0	1	0	0
BIDC Small Business Centre	36	22	13	7	1	0	4	1	0	10	0	0
Colonnade Mall	36	33	22	1	0	2	1	3	0	0	1	6
General Post Office	36	21	19	2	1	1	3	4	12	2	1	2
NVN Plaza	36	17	18	0	1	0	1	2	0	0	15	3

Figure 8: Weekday activities at each location



Location	Total number of times observed	Traffic	People activity	Animal noises	Construction	Loud Car music	Karaoke/ bar music	Other music	Bus terminal activities	Trees Rustling	Humming A.C Unit	Other
Barbados Port Authority	6	5	1	1	1	0	0	0	0	2	0	0
Berean Bible Church	6	3	3	0	0	0	2	2	0	1	0	0
BIDC Small Business Centre	6	5	2	2	0	0	0	0	0	2	0	1
Colonnade Mall	6	5	4	0	0	0	1	1	0	1	0	1
General Post Office	6	5	3	1	1	0	0	0	1	2	0	1
NVN Plaza	6	2	2	0	1	0	0	0	0	0	1	2

Figure 9: Sunday activities at each location

7.4 What are the land use characteristics of the six sites?

As expected the main land use was for commercial activities.

A range of activities was carried out at or near the monitoring sites, with commercial activity being dominant. The land use around the various sites is shown in Table 8. The Barbados Port Inc. was located in an area where both industrial and commercial activities occurred and heavy-duty vehicles passed. The Berean Bible Church was located in a commercial area that was known to have an active nightlife. The BIDC Small Business Centre was located in a commercial area and near a heavily trafficked road. The Colonnade Mall was located in the heart of Bridgetown, on Broad Street, one of the most well known streets. The General Post Office was located in a commercial area, near to two bus terminals where persons boarded and disembarked mass public transport. There were also many vendors nearby who vocally solicited persons to buy their wares. The NVN Plaza was located in a commercial area with mostly pedestrians and a few vehicles, most of which were delivery vehicles.

Table 8: Land use characteristics of the monitoring sites

Location	Type of area/land use
Barbados Port Inc.	Commercial/ Industrial
Berean Bible Church	Commercial with active night life
BIDC Small Business Centre	Commercial with busy road
Colonnade Mall	Central town
General Post Office	Commercial with bus terminals nearby
NVN Plaza	Commercial with mostly pedestrians

7.5 How do the noise levels compare with WHO guideline values for community noise?

In general the sound levels in all the areas monitored were within the WHO guidelines.

The World Health Organization's guideline for industrial, commercial shopping and traffic areas; indoors and outdoors, is an L_{eq} of 70dB with a L_{max} of 110dB over a 24 hr period. It was noted that the diverse land use within Bridgetown could present a problem when comparing it to many international standards including the World Health Organization's Community Guidelines as they often do not account for mixed

use areas but provide noise limits for individual zones/areas e.g. residential, industrial or commercial. As Bridgetown was largely a commercial area the noise limits used were for commercial areas i.e. 70dBA over a 24hr period.

In general, all the areas monitored were within the WHO guidelines for industrial, commercial shopping and traffic areas. There was one day during the monitoring period (6th June 2012) where the L_{eq} for the General Post Office site marginally exceeded the limit (70.2dB). All other values were within the specified limits. As previously indicated, the values obtained that day were irregular when compared to other noise levels that were recorded at that location during that week and had therefore been removed from further analysis.

7.6 Are the noise levels during the week statistically different to those recorded on Sundays?

The L_{eq} values recorded on Sundays were statistically different to those during the week at any given site. The values on Sundays were generally lower than those during the week

In general the data (Table 7) showed that the weekday values of the various noise descriptors were higher than those recorded on Sundays. It was noted that Berean Bible Church and BIDC Small Business Centre each had one day where the weekday L_{eq} and L_{10} values were slightly lower than their respective Sunday measurements.

For the analysis the Sunday data for each site was compared to a weekday's data for that particular site. The data was first tested for normality using histograms, the Kolmogorov–Smirnov (KS) statistic and probability plots. The histograms, K-S graphs and distribution plots are displayed in the Appendix 7. Based on the tests conducted, the data was not found to be normally distributed and the non-parametric Wilcoxon Signed Rank Test was used for the comparison analysis. In general it was found that the difference between the noise levels (weekend vs. weekday) was statically significant as the significance level (Asymp. Sig. (2-tailed)) was below 0.05. Thus if for a specific site the Sunday reading was compared to the weekday reading, both taken at the same time of day, there would be a statistical difference between the two values. The Sunday's values were generally lower than the weekday values. The results of the Wilcoxon Signed Rank Test are shown in Table 9. As mentioned earlier no sound level

monitoring was done at the Barbados Port Inc. site on Sundays as fetes were held in the vicinity on Sundays during the monitoring period.

Table 9: Results of Wilcoxon Signed Rank Test- comparing weekday Leq values with Sunday's Leq values

Test Statistics(c)					
	GPO (Tues)– GPO (Sunday)	Colonnade Mall (Wed) - Colonnade Mall (Sun)	Berean (Wed) - Berean (Sun)	BIDC (Tues)– BIDC (Sun)	NVN (Mon) - NVN (Sun)
Z	-32.600(a)	-25.344(a)	-12.009(b)	-71.698(b)	-42.218(a)
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000
a Based on negative ranks.					
b Based on positive ranks.					
c Wilcoxon Signed Ranks Test					

7.7 How do the pre-survey values compare to those from the formal survey?

For most sites the 15 minute pre-survey L_{eq} and L_{10} values were approximately 8-10dBA higher than the respective 24hr values.

The pre-survey monitoring was done during weekday mornings between 9a.m. and 11a.m. This period was busier than the overall 24hr period which would include the quieter evening and night time periods. For most sites, the 15-minute pre-survey L_{eq} and L_{10} values were approximately 8-10dBA higher than the respective 24hr values (See Figure 10 and Figure 11**Error! Reference source not found.**) and the L_{90} pre-survey values were approximately 5-15dBA higher than the 24hr L_{90} values (See Figure 12**Error! Reference source not found.**). The exception was NVN Plaza's site where the pre-survey values were marginally higher (by less than 1dBA). The difference between the L_{90} values recorded at NVN plaza during the pre-survey and the 24hr monitoring was however similar to other sites.

For the NVN Plaza monitoring site, the difference of less than 1dBA between the pre-survey and survey values, was minimal when compared to other locations. This could be due to the fact that, unlike the other sites, the activities near NVN plaza did not change as dramatically during the day when compared to the evening/night. Pedestrians usually frequent the area near NVN with limited vehicles passing. The difference between day and night/evening activities would not be as substantial when compared to other sites which have high traffic counts and more persons during the day and significantly lower traffic and people counts at night. This was reflected in the traffic count data collected from the Ministry of Transport and Work (See Appendix 6).

As previously indicated there were no pre-survey values for BIDC Small Business Centre as it had not been initially identified as a monitoring site. The average Leq for each site used in the 24hr monitoring was calculated using the equation below:

$$L_{eq} = 10\log\left(\frac{10^{\frac{L_{eq1}}{10}} + 10^{\frac{L_{eq2}}{10}} + 10^{\frac{L_{eq3}}{10}} + \ldots\ldots + 10^{\frac{L_{eqn}}{10}}}{n}\right)$$

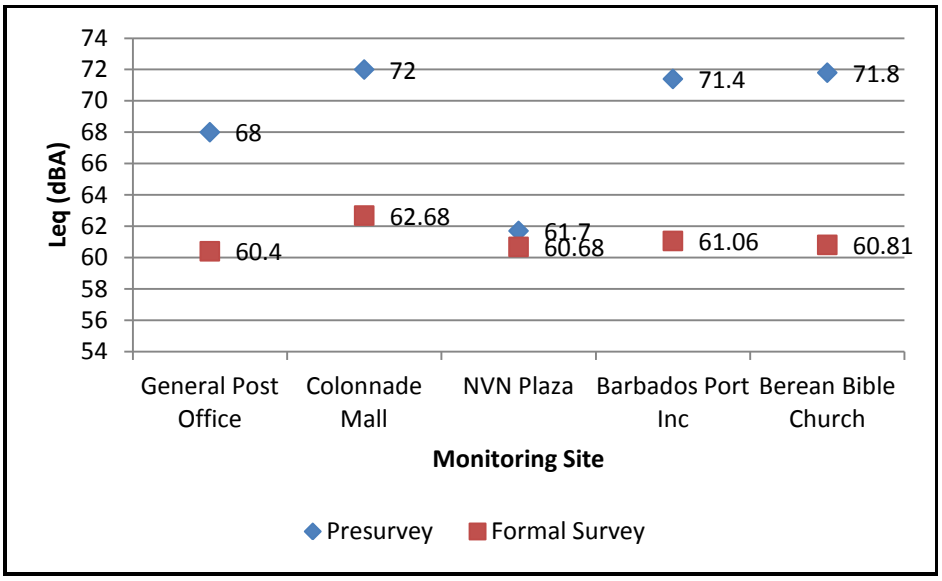


Figure 10: Comparison of pre-survey to formal survey L_{eq} values at each site

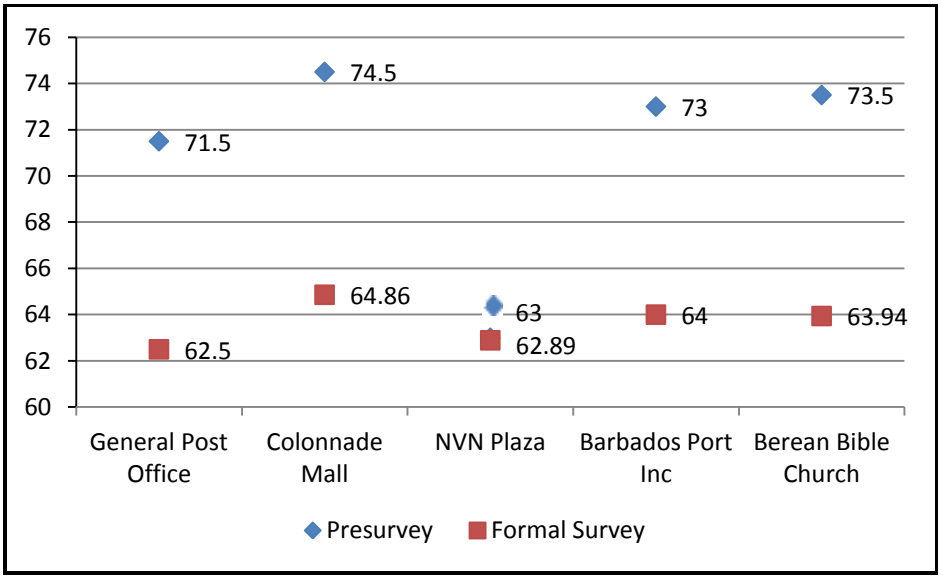


Figure 11: Comparison of pre-survey to formal survey L_{10} values at each site

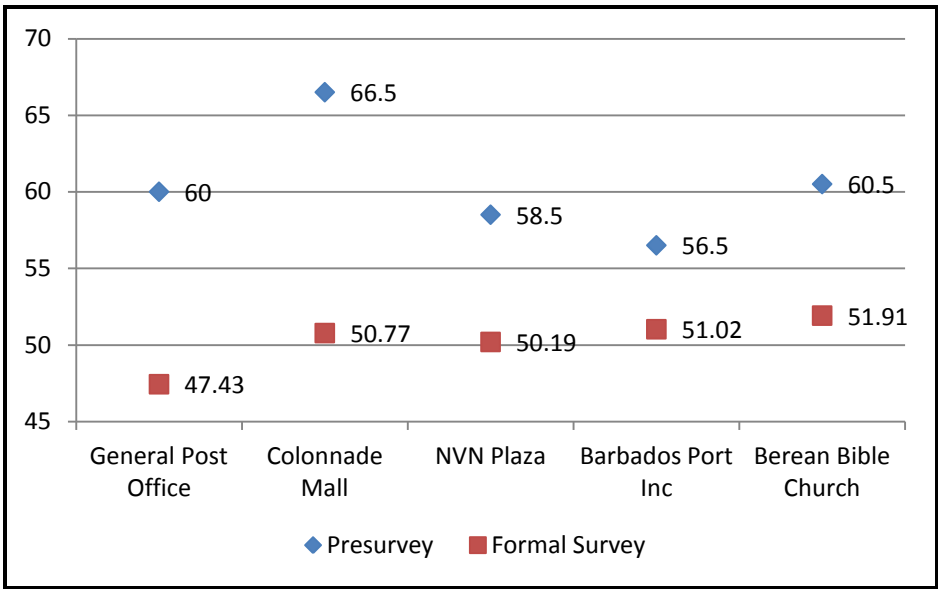


Figure 12: Comparison of Presurvey to Formal Survey L90 Values at Each Site

For future studies, the observation that short-term sample values of L_{eq}, L_{10} and L_{90} taken during busy periods were higher than 24hr values for a given site can inform effective use of resources. Depending on the purpose of the study/investigation, further monitoring may only be required for areas where the short-term sample value(s) of interest e.g. L_{eq}, L_{10} and L_{90} during the busiest/noisiest periods exceeds desired limits.

7.8 Is there a correlation between the traffic counts and the noise levels recorded?

The relationship between L_{eq} and traffic counts was investigated using Spearman's rank order correlation. There was a strong, positive correlation between the two variables with high traffic counts being associated with high L_{eqs}.

The correlation between traffic counts and noise levels was investigated using the Spearman's rank order correlation for each site as well as overall (for all sites). As previously indicated in Section 7.6, the sound level data was not found to be normally distributed and as such a non-parametric correlation, Spearman's rank order correlation, was used to determine the strength and direction of the relationship between the two variables. The sign (positive or negative) indicated the direction of the relationship. The ranges suggested by Cohen (1988) were used to describe the strength of the relationship (See Table 10).

Table 10: Ranges used in description of the strength of the relationship (Cohen 1988)

Range of r values	Interpretation
r=.10 to .29 or r=-.10 to -.29	small
r=.30 to .49 or r=-.30 to -.49	medium
r=.50 to 1.0 or r=-.50 to -.1.0	large

Before the raw data could be analyzed some manipulation of the data was required as the traffic data and the sound level data were logged at different rates. The traffic counts were logged every hour and the noise level data every 10 seconds. There was also a challenge in aligning the data as the sound level meter did not begin monitoring at the same time as the traffic counters. A significant amount of computation would have been required to convert all data from the 10 second L_{eqs} to 1 hour L_{eqs} and align all the data. It was noted however, that it would be easier to align all the sound level data collected on Sundays with the traffic data as both started at the same time (i.e. midnight). As the Sunday data required the least amount of computation the Sunday data collected at each site was used to investigate the correlation between L_{eq} and traffic counts. The basic L_{eq} equation was used to convert the 10 second L_{eqs} to 1hour L_{eqs} and is stated below:

$$L_{eq} = 10\log\left(\frac{10^{\frac{L_{eq1}}{10}} + 10^{\frac{L_{eq2}}{10}} + 10^{\frac{L_{eq3}}{10}} + \ldots\ldots + 10^{\frac{L_{eqn}}{10}}}{n}\right)$$

In most instances there was a strong, positive correlation. The exception was the BIDC Small Business Centre monitoring site where there was a weak positive correlation. Scatter plots were also used to give a visual of the raw data. Table 11 to Table 16 and Figure 13**Error! Reference source not found.** to Figure 18**Error! Reference source not found.** show the results of the correlation analysis and the scatter plots.

At the General Post Office (GPO) site there was a strong, positive correlation between the hourly Leqs and the hourly traffic counts [r=0.710, n=24, p<0.0005]. Therefore as traffic counts increased so did the L_{eqs}. The results of the analysis and the scatter plot are below:

Table 11: Correlation analysis of hourly L_{eqs} with hourly traffic counts at GPO

			GPO_LEQ	GPO_TRAF
Spearman's rho	GPO_LEQ	Correlation Coefficient	1.000	.710(**)
		Sig. (2-tailed)	.	.000
		N	24	24
	GPO_TRAF	Correlation Coefficient	.710(**)	1.000
		Sig. (2-tailed)	.000	.
		N	24	24
**** Correlation is significant at the .01 level (2-tailed).**				

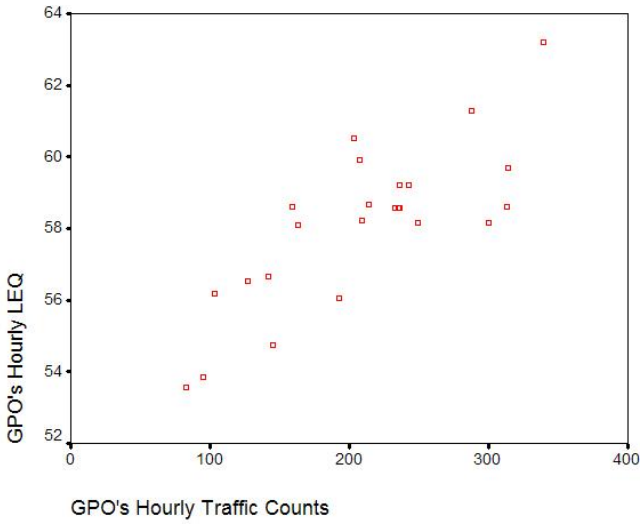


Figure 13: Scatter plot of hourly L_{eqs} at GPO versus hourly traffic counts at GPO

At the Colonnade Mall site there was a strong, positive correlation between the hourly L_{eqs} and the hourly traffic counts [r=0.742, n=24, p<0.0005). Therefore as traffic counts increased so did the L_{eqs}. The results of the analysis and the scatter plot are below:

Table 12: Correlation analysis of hourly L_{eqs} with hourly traffic counts at Colonnade Mall

			COLL_LEQ	COLL_TRA
Spearman's rho	COLL_LEQ	Correlation Coefficient	1.000	.742(**)
		Sig. (2-tailed)	.	.000
		N	24	24
	COLL_TRA	Correlation Coefficient	.742(**)	1.000
		Sig. (2-tailed)	.000	.
		N	24	24
**** Correlation is significant at the .01 level (2-tailed).**				

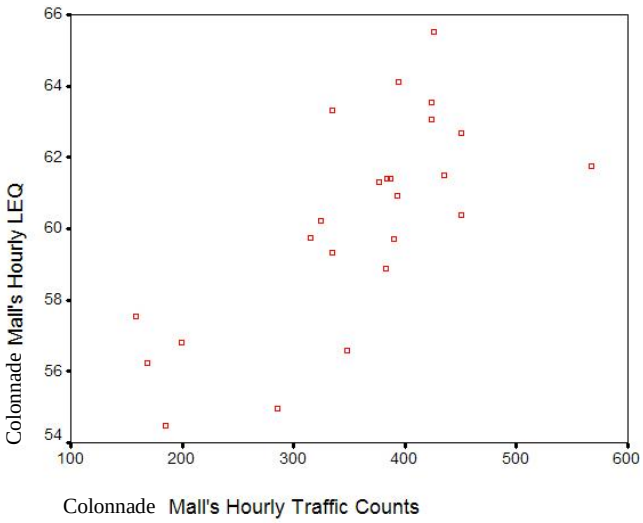


Figure 14: Scatterplot of hourly L_{eqs} versus hourly traffic counts at the Colonnade Mall

At the NVN Plaza site there was a strong, positive correlation between the hourly L_{eqs} and the hourly traffic counts [r=0.620, n=24, p<0.0005). Therefore as traffic counts increased so did the L_{eqs}. The results of the analysis and the scatter plot are below:

Table 13: Correlation analysis of hourly L_{eqs} with hourly traffic counts at NVN Plaza

			NVN_LEQ	NVN_TRAF
Spearman's rho	NVN_LEQ	Correlation Coefficient	1.000	.620(**)
		Sig. (2-tailed)	.	.001
		N	24	24
	NVN_TRAF	Correlation Coefficient	.620(**)	1.000
		Sig. (2-tailed)	.001	.
		N	24	24
**** Correlation is significant at the .01 level (2-tailed).**				

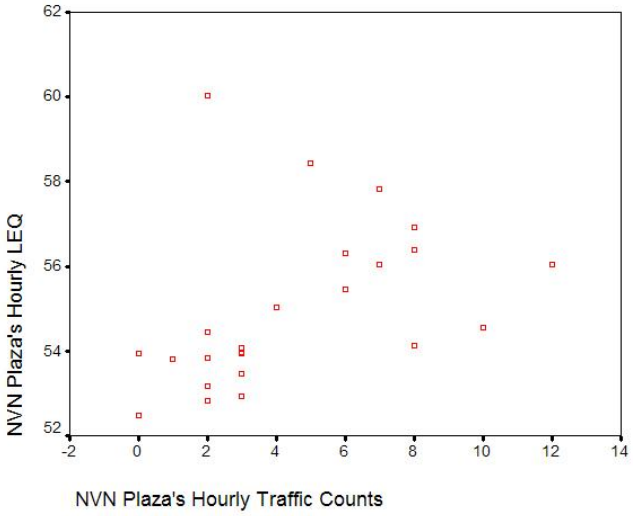


Figure 15: Scatter plot of hourly L_{eqs} versus hourly traffic counts at the NVN Plaza

At the Berean Bible Church site there was a strong, positive correlation between the hourly L_{eqs} and the hourly traffic counts [r=0.710, n=24, p<0.0005). Therefore as traffic counts increased so did the L_{eqs}. The results of the analysis and the scatter plot are below:

Table 14: Correlation analysis of hourly L_{eqs} with hourly traffic counts at Berean Bible Church

			BER_LEQ	BER_TRAF
Spearman's rho	BER_LEQ	Correlation Coefficient	1.000	.786(**)
		Sig. (2-tailed)	.	.000
		N	24	24
	BER_TRAF	Correlation Coefficient	.786(**)	1.000
		Sig. (2-tailed)	.000	.
		N	24	24
**** Correlation is significant at the .01 level (2-tailed).**				

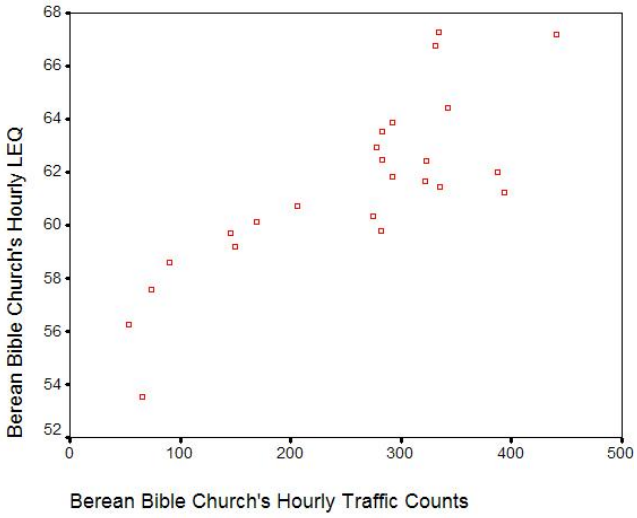


Figure 16: Scatterplot of hourly L_{eqs} versus hourly traffic counts at Berean Bible Church

At the BIDC Small Business Centre site there was a weak, positive correlation between the hourly L_{eqs} and the hourly traffic counts [r=0.278, n=24, p=.188). Therefore as traffic counts increased so did the L_{eqs} but the relationship between the two variables was weak. The results of the analysis and the scatter plot are below:

Table 15: Correlation analysis of hourly L_{eqs} with hourly traffic counts at BIDC Small Business Centre

			BIDC_LEQ	BIDC_TRA
Spearman's rho	BIDC_LEQ	Correlation Coefficient	1.000	.278
		Sig. (2-tailed)	.	.188
		N	24	24
	BIDC_TRA	Correlation Coefficient	.278	1.000
		Sig. (2-tailed)	.188	.
		N	24	

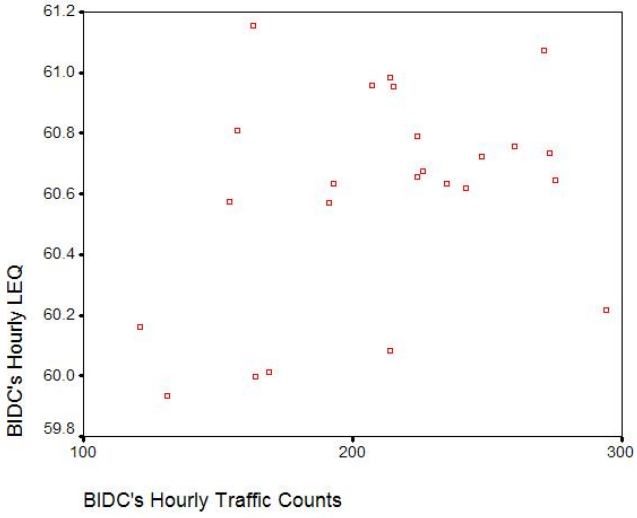


Figure 17: Scatterplot of hourly L_{eqs} versus hourly traffic counts at the BIDC Small Business Centre

All of the Sunday hourly traffic data and associated L_{eqs} were compiled and an overall correlation analysis was done. It was found that there was a strong, positive correlation between the overall hourly L_{eqs} and the hourly traffic counts [r=0.779, n=120, p<0.0005). Therefore as traffic counts increased so did the L_{eqs}. The results of the analysis and the scatter plot are below:

Table 16: Correlation analysis of hourly L_{eqs} with hourly traffic counts for all sites combined

			LEQ	TRAFFIC
Spearman's rho	LEQ	Correlation Coefficient	1.000	.779(**)
		Sig. (2-tailed)	.	.000
		N	120	120
	TRAFFIC	Correlation Coefficient	.779(**)	1.000
		Sig. (2-tailed)	.000	.
		N	120	120
**** Correlation is significant at the .01 level (2-tailed).**				

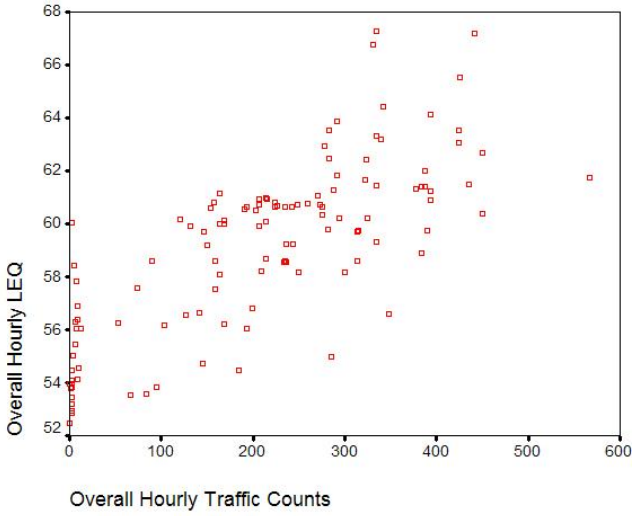


Figure 18: Scatterplot of hourly L_{eqs} versus hourly traffic counts for all sites combined

It should be noted that the above results only indicated that high traffic counts and high sound levels tend to occur together. Although it was very likely that the traffic volume caused the changes in sound level, the study was not designed to look at what caused the increase in sound level. For example, increased traffic counts could mean an increase in other sources of noise e.g., person related sounds and general business activity which could instead be the direct factor(s) for increased sound levels. The study did not aim to determine which of the sources caused the changes in sound levels. So in summary, the study clearly found that an increase of traffic volume is associated with an increase in noise levels however, the study was not designed to identify if the link was a direct or indirect link or merely a coincidence.

7.9 Preliminary Noise Map

The target area, as shown in Appendix 3, was divided into zones using the grid function within Google Earth, the program used to obtain the satellite imagery. This was done as the ISO 1996-2 standard recommended that monitoring sites be well spaced and suggested the use of a grid in determining monitoring sites. Each zone was square, approximately ¼ mile by ¼ mile. Pre-survey monitoring was then conducted in various zones to provide guidance in the selection of the 24hr monitoring sites as well as other information. For further information on the pre-survey, the report entitled "Bridgetown Noise Characterization Pre-Survey Report" should be referenced.

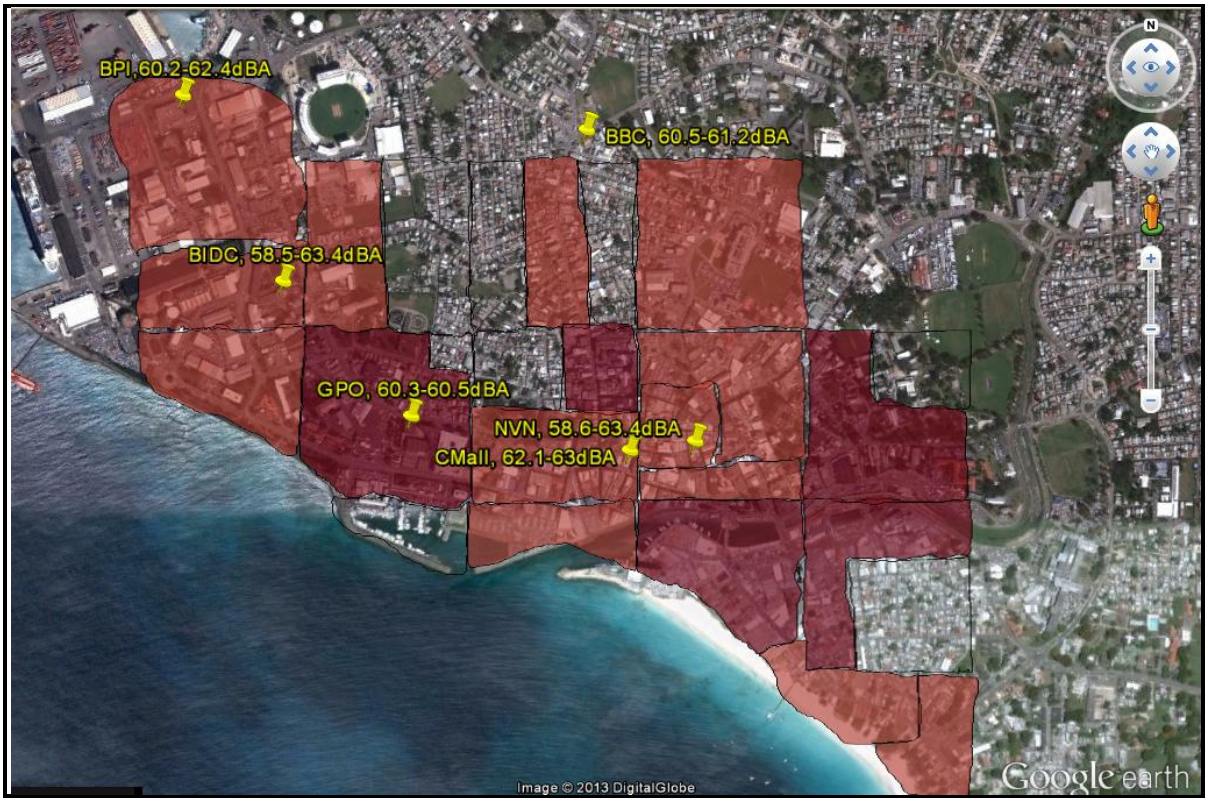
Based on the data collected during the pre-survey, zones or areas with similar activities had very similar sound level readings. Using this information, zones which had not been monitored during the formal survey were given the same sound level range as a zone with similar activities that had been measured. The average weekday L_{eq} was used to create the preliminary or rough noise map based on the colour codes in ISO-1996-2 (See Figure 19). The range of Leq values actually recorded at each site during the week was also indicated on the map. The equation used to calculate the average L_{eq} is stated below.

$$L_{eq} = 10\log\left(\frac{10^{\frac{L_{eq}1}{10}} + 10^{\frac{L_{eq}2}{10}} + 10^{\frac{L_{eq}3}{10}} + \ldots\ldots + 10^{\frac{L_{eq}n}{10}}}{n}\right)$$

This map is only preliminary in nature and can serve as a starting point for further study as it can identify possible hotspots. If a zone or a similar zone was not measured during monitoring, no colour was applied. This occurred for residential areas as no suitable location could be found with a flat roof. To produce a more scientific map further training in noise mapping and data on the topography would be needed.

Table 17: ISO 1996-2 colour codes

Noise Zone	Colour	Colours of ranges observed
Below 35	Light Green	
35-40	Green	
40-45	Dark Green	
45-50	Yellow	
50-55	Ochre	
55-60	Orange	
60-65	Cinnabar	
65-70	Carmine	
70-75	Lilac red	
75-80	Blue	
80-85	Dark blue	



BPI- Barbados Port Inc, BBC-Berean Bible Church,	BIDC- Barbados Investment Development Corporation Small Business Centre
GPO- General Post Office,	CMall- Colonnade Mall
NVN- NVN Plaza	BBC-Berean Bible Church

Figure 19: Preliminary Noise Map based on Activity within Zones for Weekdays

7.10 Discussion

For industrial, commercial shopping and traffic areas, (indoors and outdoors) the World Health Organization's guidelines indicated that the noise limits over a 24hr period are an L_{eq} of 70dB and a L_{max} (maximum) of 110dB. In general, the sound levels in all the areas monitored met the WHO guidelines. There was one day during the monitoring period (6th June 2012) where the L_{eq} for the General Post Office site marginally exceed the limit (70.2dB). All other values were within the specified limits. The equivalent noise level (L_{eq}) for the six sites ranged from 55.3 to 70.2dBA, the L_{max} from 82.8 to 106.2dBA, the L_{10} from 55.5 to 74.0, and the L_{cpeak} ranged from 106.4 dBA to 127.0.

The two most observed sources of noise were traffic and people related sounds (e.g. talking or soliciting of customers). As would be typical in towns, the areas were mainly used for commercial activities with some having added types of activities e.g. industrial, entertainment or mass transportation activities. The intent of the study was to monitor at least one of the residential areas but no suitable location with a flat, secure space could be identified. As expected, the L_{eq} values recorded on Sundays were generally lower than those during the week and L_{eq} values increased with higher traffic counts. In addition, pre-survey values that were taken during busy periods at a particular site were generally higher than the 24hr values taken at the same site.

8 Conclusion & Recommendations

8.1 Conclusions

The following conclusions were made:

- In general the noise levels persons were exposed to while in Bridgetown, at the sites monitored, were within W.H.O. guidelines for community noise for industrial, commercial shopping and traffic areas.
- Traffic noise and people related noises were the main observed activities near the monitoring sites.
- In general, the weekday values of the various noise descriptors were 1-8 dBA higher than those recorded on Sundays.
- In general, there was a strong, positive correlation between the L_{eq} and traffic counts. In other words, high L_{eqs} were associated with high traffic counts.

8.2 Recommendations

The following recommendations are made:

- In order to maintain the sound levels in Bridgetown at acceptable levels, future projects or programmes planned for Bridgetown should take sound levels into consideration.
- Similar baseline data should be collected for other areas in Barbados.
- Depending on the purpose of the study/investigation, only areas where short-term sampling during the busiest/noisiest periods exceeds desired limits may require further long-term monitoring. This could be part of the criteria for site selection, as it would increase the efficiency with which resources are used.

- In future projects/programmes where traffic counts will be analyzed with the sound levels it would be best if both devices start at the same time and log at the same rate. This would allow for easier data analysis and reduce the amount of data manipulation necessary.
- At least one additional portable noise monitoring option or noise monitoring station should be purchased. Currently (Jan, 2015) there is only one portable noise monitoring option. This kit is necessary for monitoring noise levels outdoors as it protects the sound level meter from damage due to the weather and provides some security against vandalism/theft. As a result, only one site can be monitored at any point in time thereby decreasing efficiency.
- A rain gauge should be purchased as this would provide information on how much rain fell during monitoring. During sound level monitoring there should be no heavy rain and preferably no rain, as increased noise such as noise associated with vehicle tyres passing through puddles, the whistling/howling of wind or rustling of trees may impact on the results. Additionally sound level meters have good accuracy over manufacturer specified relative humidity levels. According to Bruel and Kjaer, the manufacturers of the sound level meters used, sound level readings for this device have an error of 0.5dB or less when the relative humidity is between 30% and 90%.
- Further training and resources should be obtained to allow continuous or at least more regular monitoring of sound levels in Barbados. Options such as permanent monitoring sites, remote data collection and the production of scientific noise maps should be considered for future endeavours.

9 References

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10 Appendices

Appendix 1: Data collection form used during monitoring

Environmental Protection Department

Noise Measurement Report

Bridgetown Noise Characterization Study Survey 2012

GPS Coordinates: ……Date: …..... Day:…….

Address/ Location: ……

Zone: …… *Record # in meter:* ……

Officers: ……..

Site Description:

Description of location *(Type of area/zone, activities conducted, topography, nature of ground):*

……

……

Sound Description:

Description and location of (major) sources of ambient noise: *(cars, amplified music, steady tone, impulsive, etc.)*: …….

……..

Description and location of extraneous sources of ambient noise: *(e.g. parade, etc.)*:

……..

……..

Instruments used:

☐ Brüel & Kjær 2236 ☐ Brüel & Kjær 2238 ☐ Quest SoundPro SP DL-2

☐ BruelKjaer 4231 Calibrator ☐ QC-10 Calibrator ☐ Windscreen

☐ Kestrel Weather monitor ☐ Dosimeter

☐ Portable noise monitoring option –Type 3571

☐ Other(s)……

Equipment Calibration

Time of calibration (before monitoring)……..……..

Time of calibration check (after monitoring) ……..……..

Comments: ……..

General Weather Description:

	Date	Date	Date	Date
Precipitation (Y/N)				
Wind Direction				
Wind speed				
Relative humidity				
Temperature				
Atmospheric Pressure				
Cloud Cover				

Sketch of Site (showing sampling location)

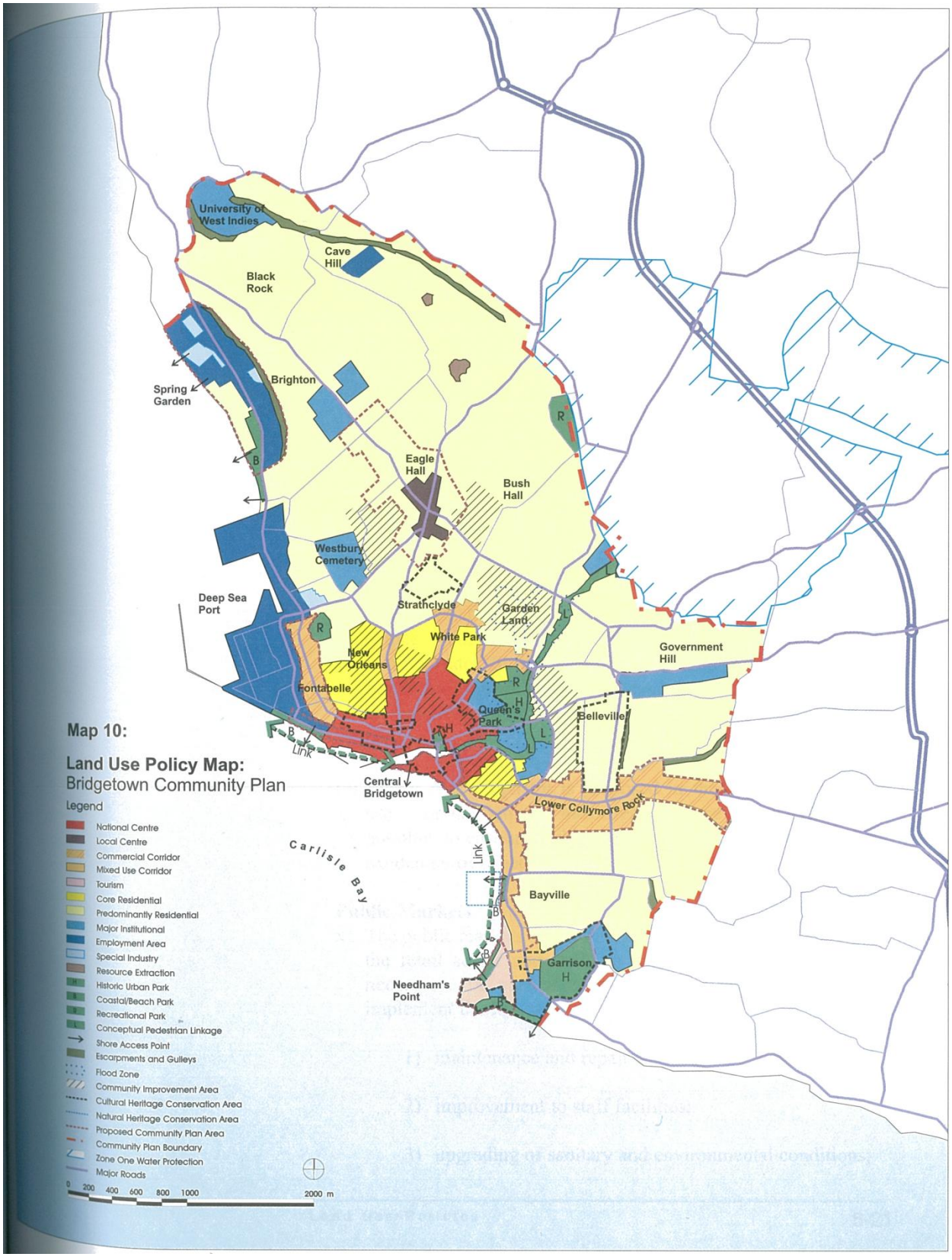
Measurement of Ambient Noise Levels

Time (Start-Finish)	Leq (dBA)	L10 (dBA)	L90 (dBA)	Lmin (dBA)	Lmax (dBA)	Lcpeak (dBC)	Height above ground level	Distance from nearest reflective surface (not the ground)

Noise log sheet

TIME	COMMENTS

Appendix 2: Bridgetown as delineated in Barbados' Physical Development Plan (2003)



Appendix 3: Targeted Area for Bridgetown Noise Project

Appendix 4: Dates the Traffic Counters were Deployed

Site	Dates deployed
General Post Office (Cheapside)	15th June 2012-23rd June 2012
Colonnade Mall (Broad Street)	11th July 2012- 22nd July 2012
Barbados Port Inc (Prescod Boulevard)	22nd June 2012 -2nd July 2012
NVN Plaza (Victoria Street)	4th July 2012 – 12thJuly 2012
Berean Bible Church (Barbarees Hill)	14th July 2012- 17th July 2012
BIDC Small Business Centre (Fontabelle)	24th July 2012-2nd August 2012

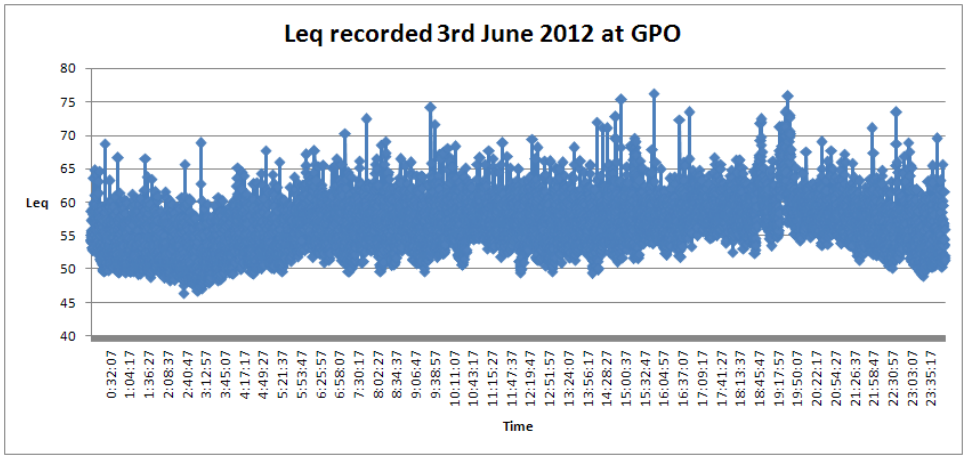
Appendix 5: Raw data of sound levels observed at each location

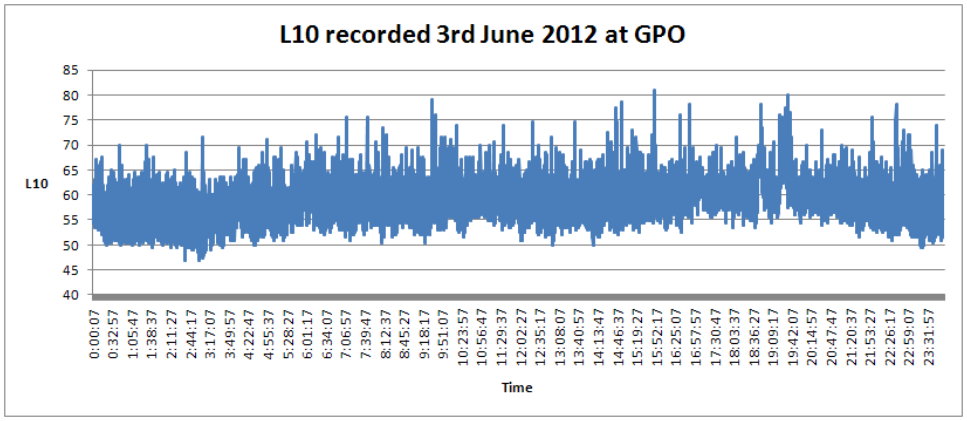
General Post Office -3rd June 2012

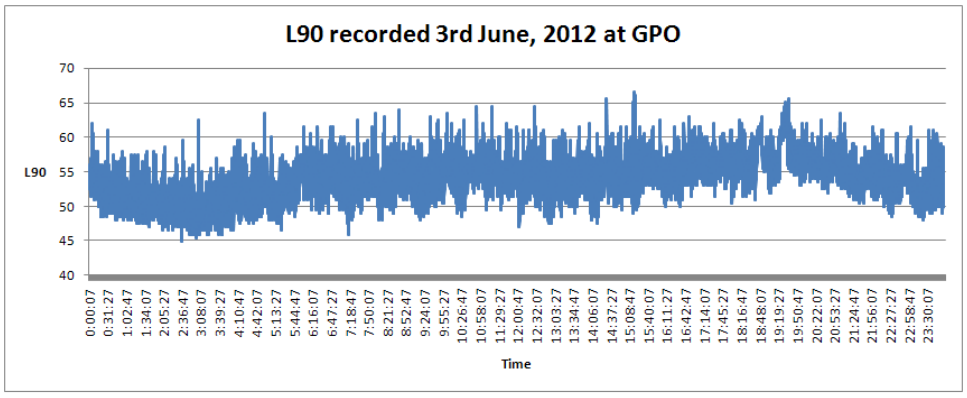
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 30-110 dB
RMS: A Peak: C
RECORD NO.: 1

6/3/2012 0:00
Pauses 0
Overload 0.0 %
MaxP 108.7 dB
MaxL 89.1 dB
MinL 43.5 dB
Leq 58.5 dB
SEL 109.1 dB
LEPd (Te= 7h30) 58.2 dB
L10 61.0 dB
L50 55.0 dB
L90 48.5 dB







General Post Office -4th June 2012

Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/4/2012 8:48
Elapsed Time 0024:02:40
Pauses 0
Overload 0.0 %
MaxP 112.4 dB
MaxL 87.3 dB
MinL 41.9 dB
Leq 60.3 dB
SEL 109.7 dB
LEPd (Te= 7h30) 60.0 dB
L10 62.5 dB
L50 58.5 dB
L90 46.0 dB

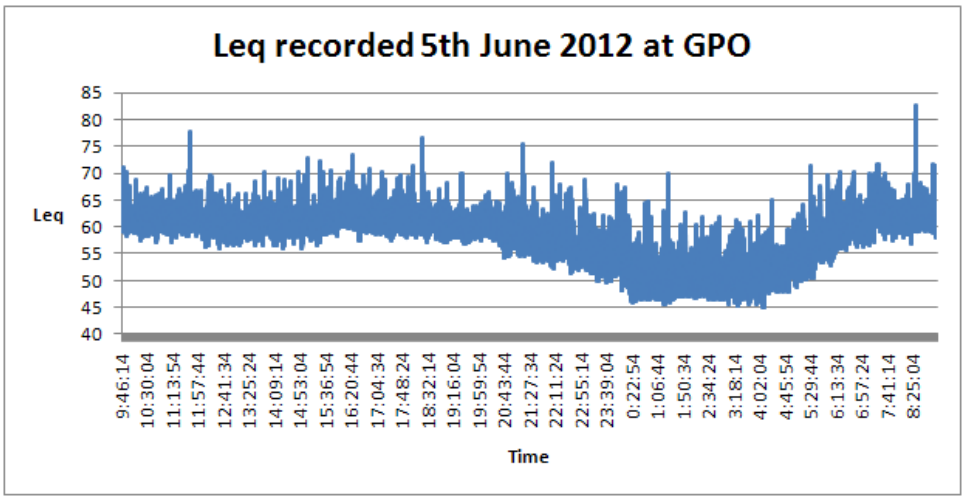
Inadvertently the sound level meter was only set to log the overall results and not the 10second data required to plot the graphs.

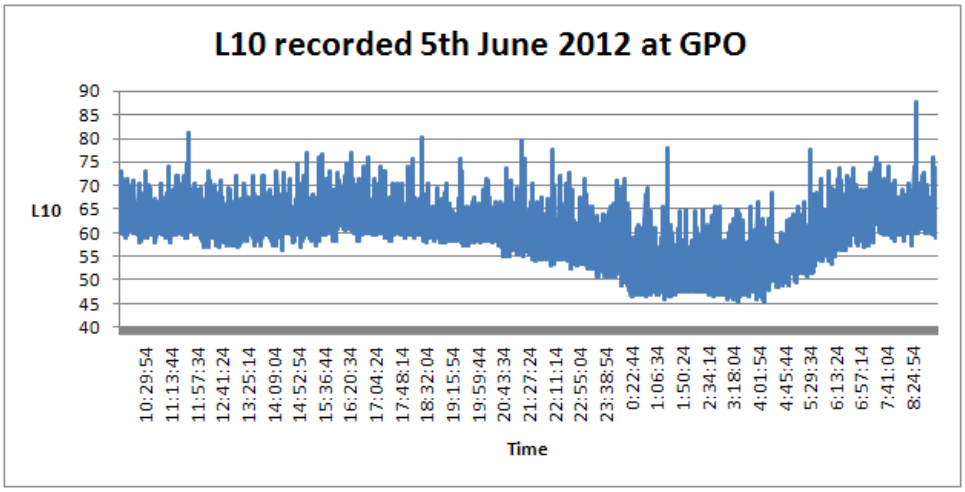
General Post Office -5th June 2012

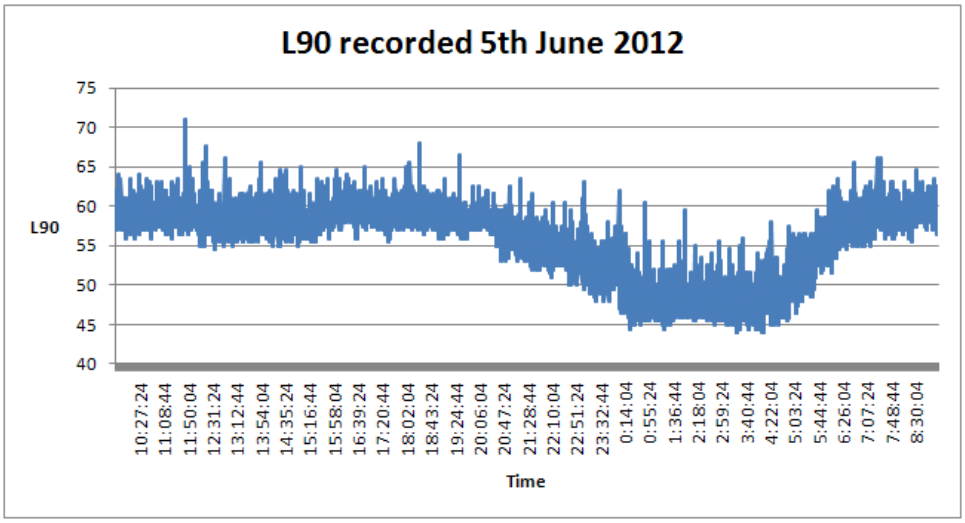
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/5/2012 9:46
Elapsed Time 0023:22:02
Pauses 0
Overload 0.0 %
MaxP 112.8 dB
MaxL 90.6 dB
MinL 43.2 dB
Leq 60.5 dB
SEL 109.7 dB
LEPd (Te= 7h30) 60.2 dB
L10 62.5 dB
L50 58.5 dB
L90 48.5 dB





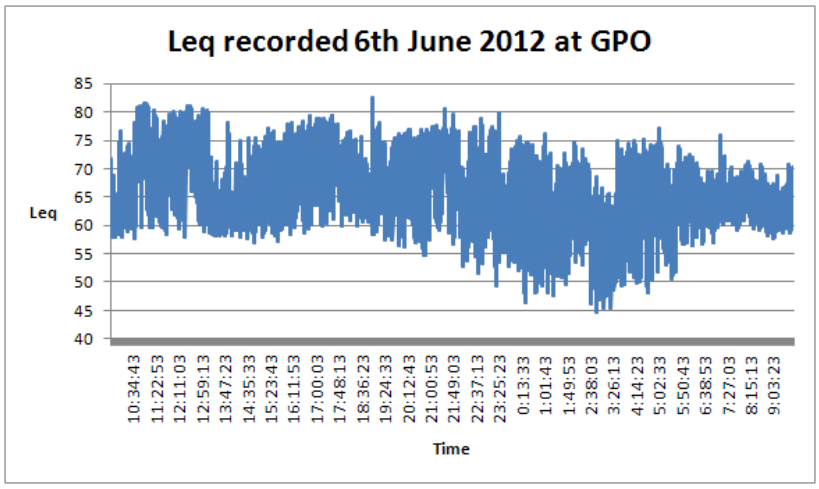


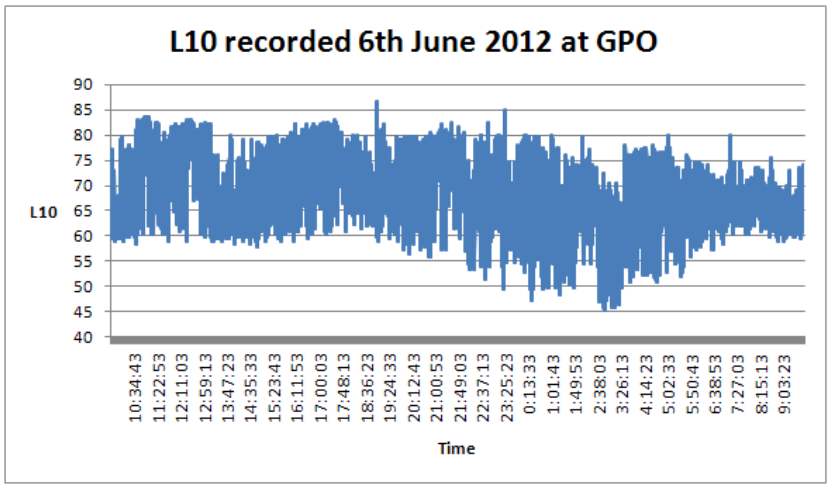
General Post Office -6th June 2012

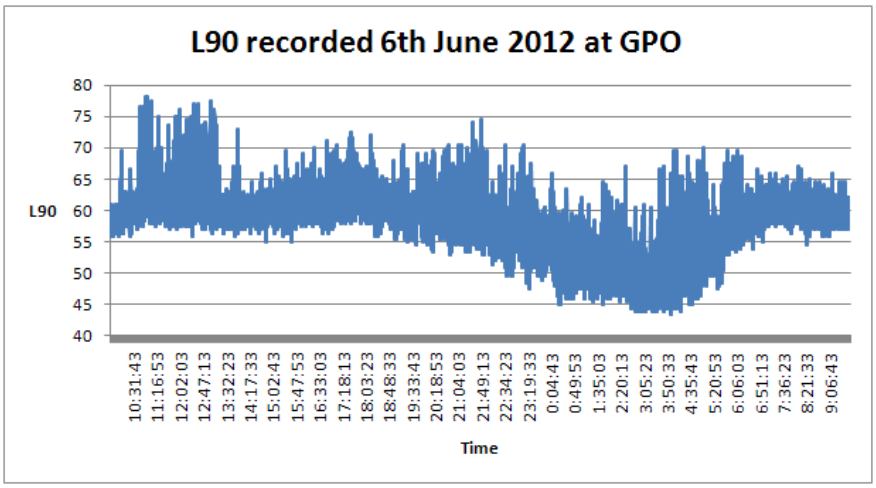
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/6/2012 9:46
Elapsed Time 0024:24:42
Pauses 0
Overload 0.0 %
MaxP 112.6 dB
MaxL 88.8 dB
MinL 43.1 dB
Leq 70.2 dB
SEL 119.7 dB
LEPd (Te= 7h30) 69.9 dB
L10 74.0 dB
L50 62.5 dB
L90 54.5 dB





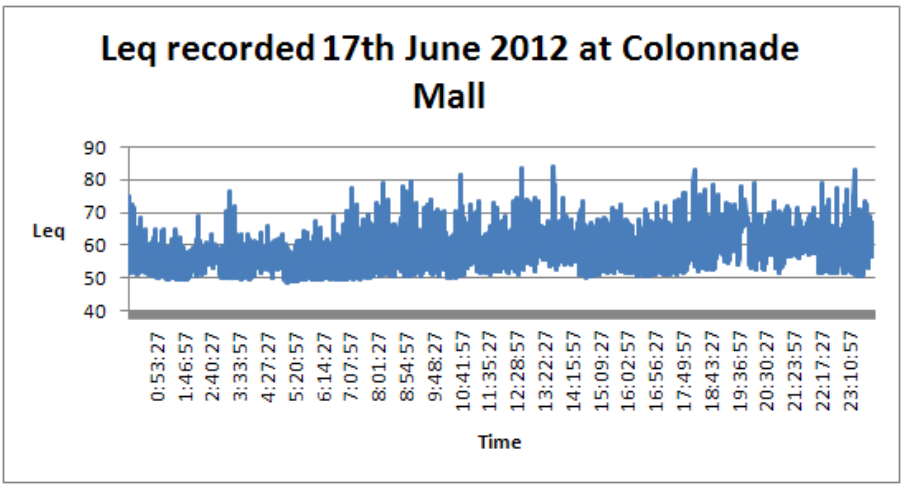


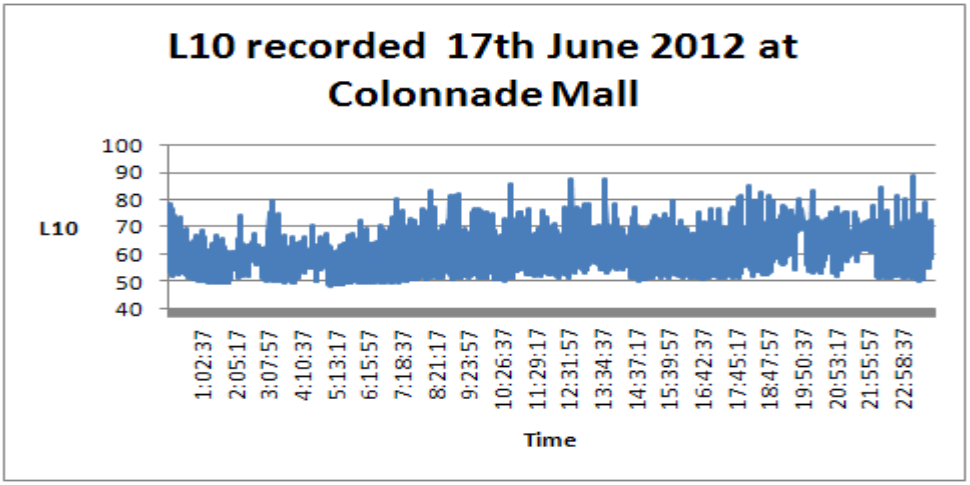
Colonnade Mall – 17th June 2012

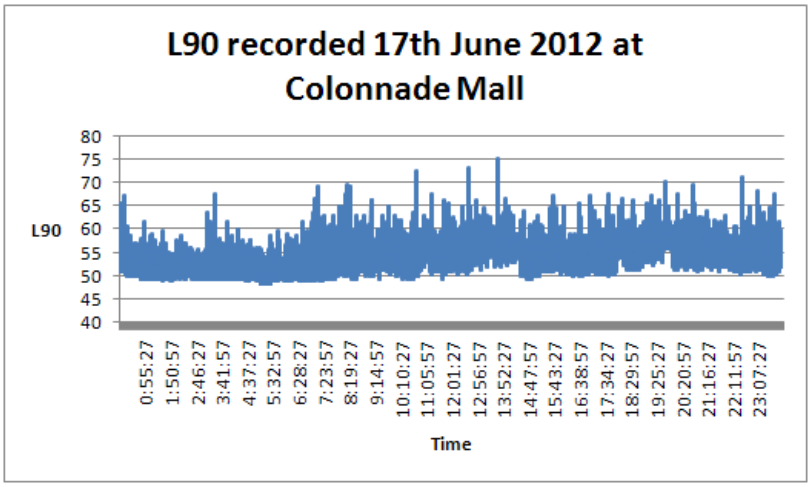
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/17/2012 0:00
Elapsed Time 0031:40:10
Pauses 0
Overload 0.0 %
MaxP 121.1 dB
MaxL 92.6 dB
MinL ---.- dB
Leq 60.9 dB
SEL 111.5 dB
LEPd (Te= 7h30) 60.6 dB
L10 62.5 dB
L50 55.5 dB
L90 50.5 dB





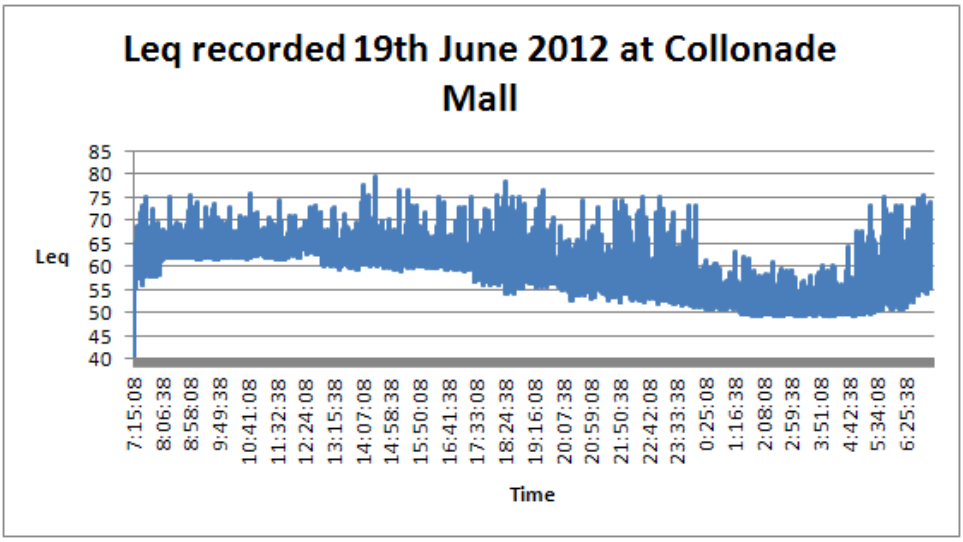


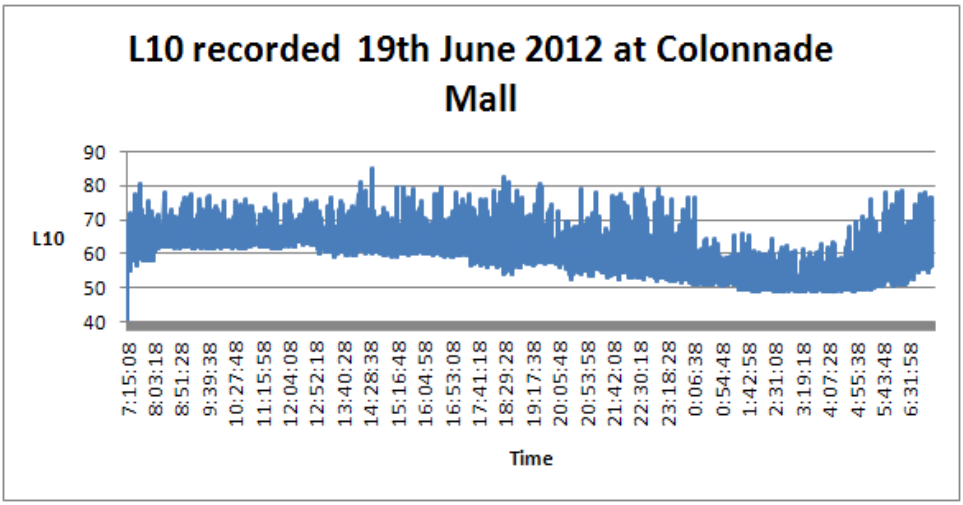
Colonnade Mall- 19th June 2012

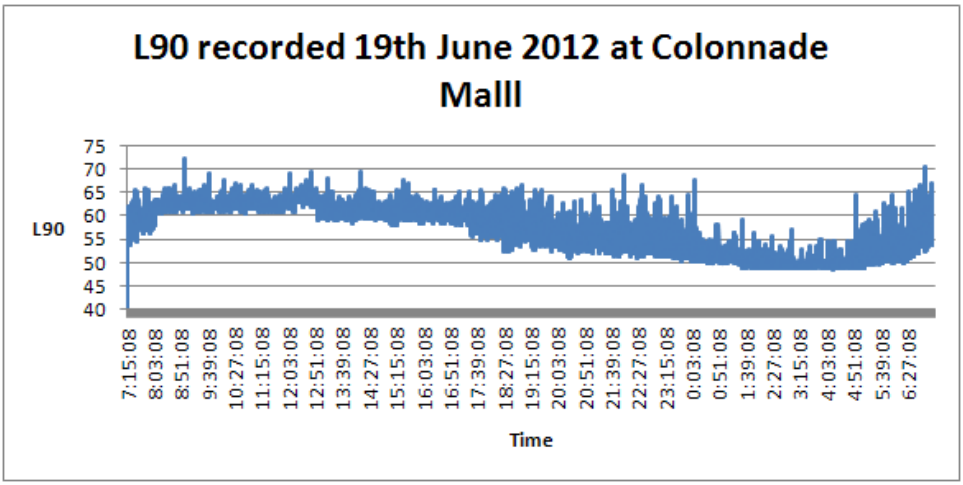
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/19/2012 7:15
Elapsed Time 0024:30:07
Pauses 0
Overload 0.0 %
MaxP 108.2 dB
MaxL 87.8 dB
MinL ---.- dB
Leq 62.1 dB
SEL 111.6 dB
LEPd (Te= 7h30) 61.8 dB
L10 64.5 dB
L50 59.5 dB
L90 50.0 dB





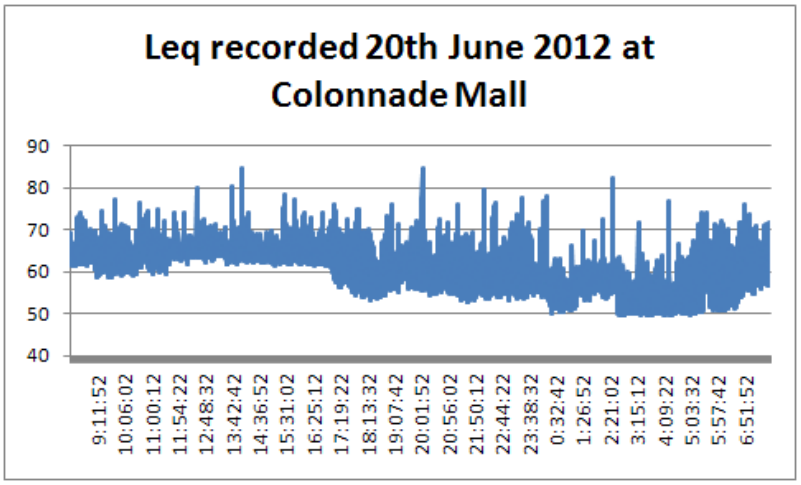


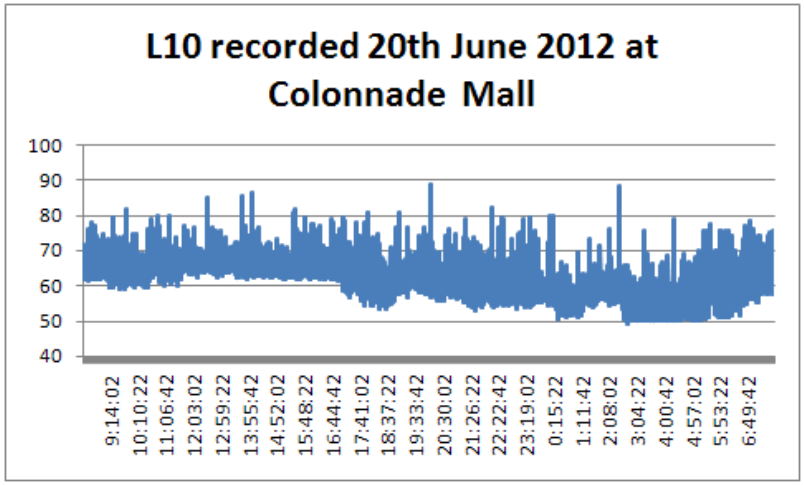
Colonnade Mall- 20th June 2012

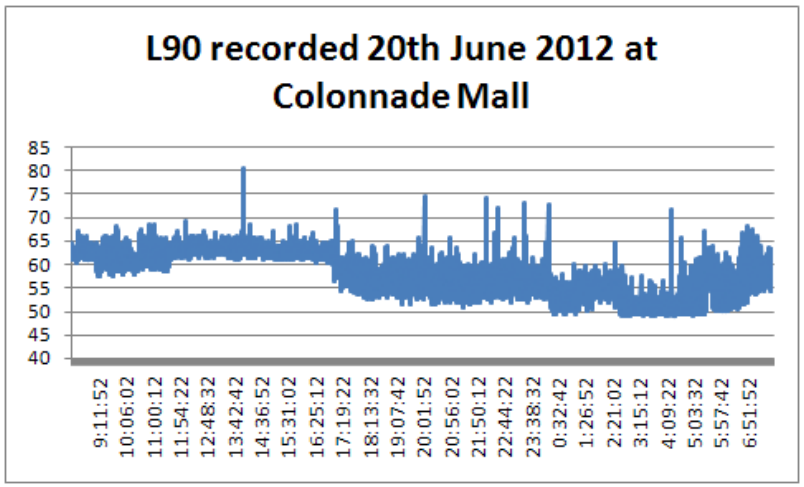
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/20/2012 8:17
Elapsed Time 0023:25:45
Pauses 0
Overload 0.0 %
MaxP 107.2 dB
MaxL 93.1 dB
MinL 48.6 dB
Leq 63.0 dB
SEL 112.3 dB
LEPd (Te= 7h30) 62.7 dB
L10 65.5 dB
L50 59.5 dB
L90 52.0 dB





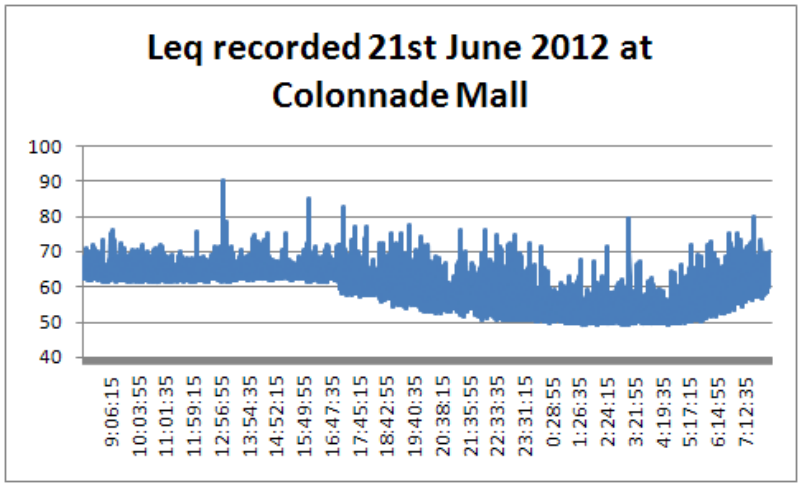


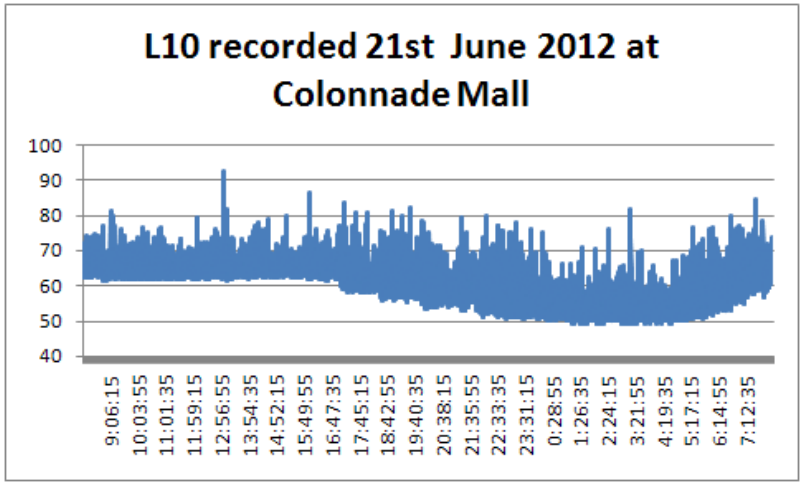
Colonnade Mall- 21st June 2012

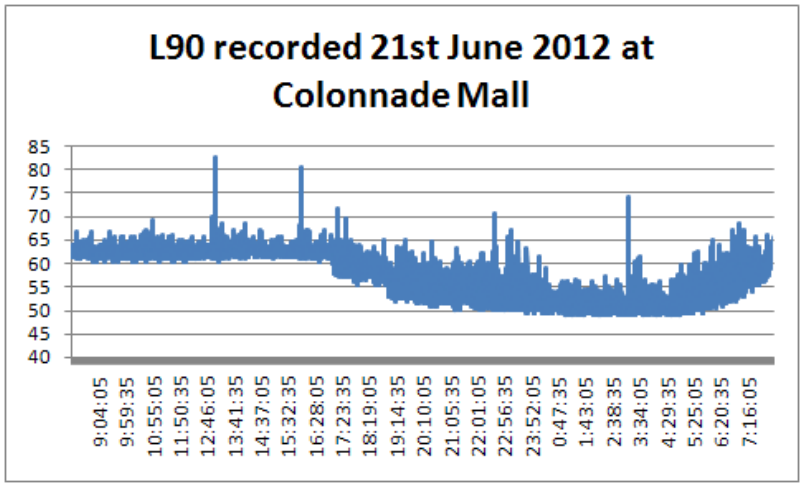
Brüel & Kjær	
SLM Type 2236	
SETTINGS:	

F	40-120 dB
RMS: A	Peak: C
OVERALL RESULTS:	

	6/21/2012 8:08
Elapsed Time 0024:07:43	
Pauses	0
Overload	0.0 %
MaxP	106.4 dB
MaxL	95.4 dB
MinL	48.4 dB
Leq	62.9 dB
SEL	112.3 dB
LEPd (Te= 7h30)	62.6 dB
L10	64.5 dB
L50	59.5 dB
L90	50.0 dB





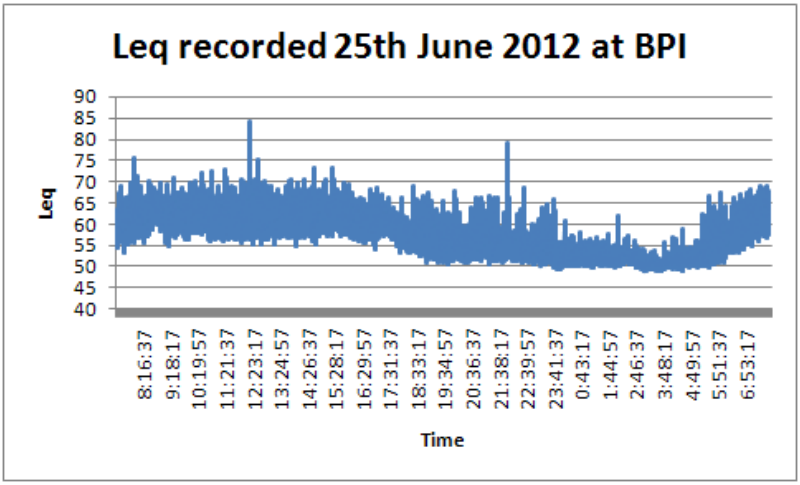


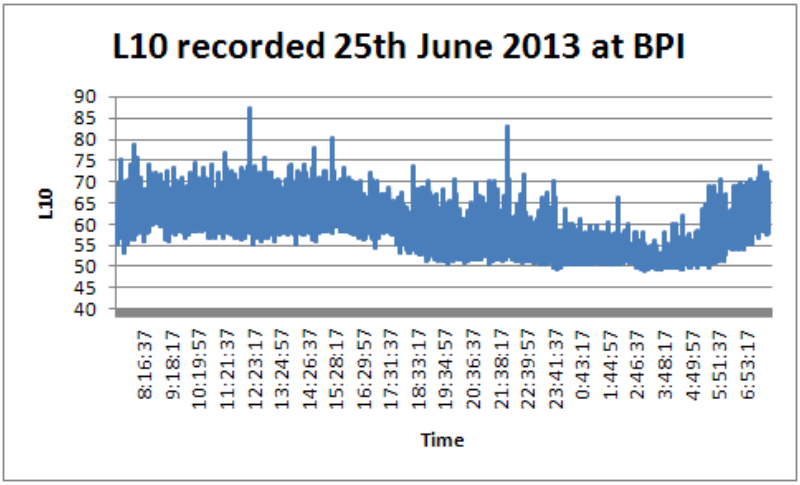
Barbados Port Inc.- 25th June 2012

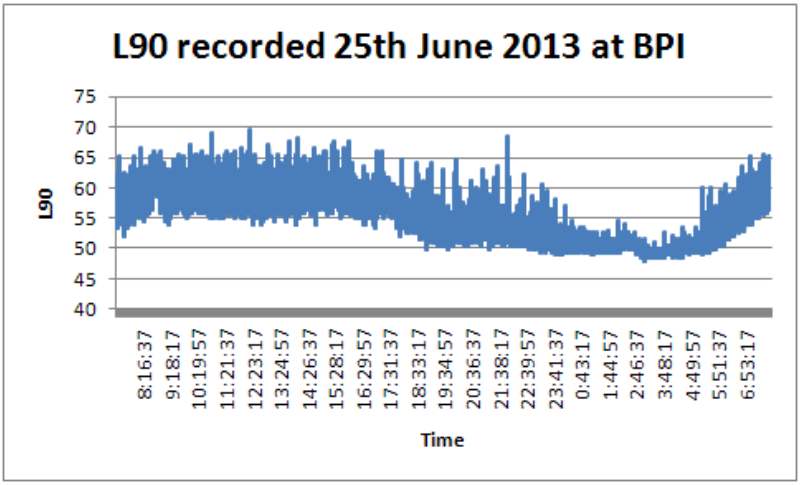
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
RECORD NO.: 1

6/25/2012 7:15
Elapsed Time 0024:36:14
Pauses 0
Overload 0.0 %
MaxP 113.0 dB
MaxL 90.2 dB
MinL 47.6 dB
Leq 60.2 dB
SEL 109.7 dB
LEPd (Te= 7h30) 59.9 dB
L10 63.0 dB
L50 57.0 dB
L90 50.5 dB





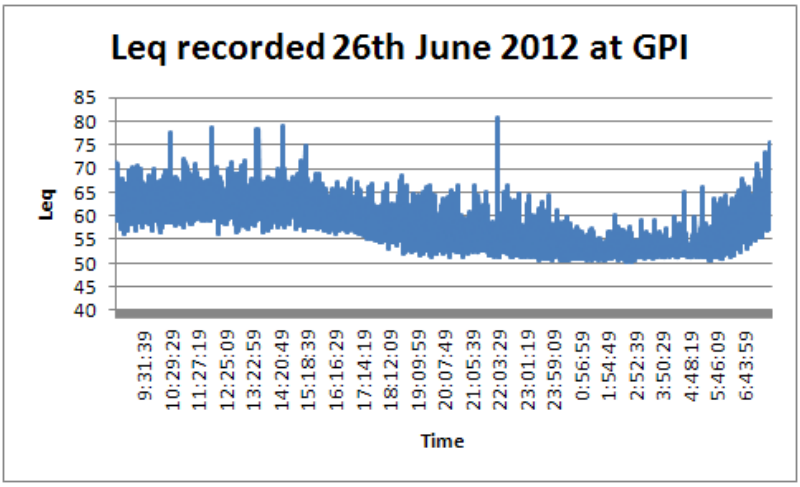


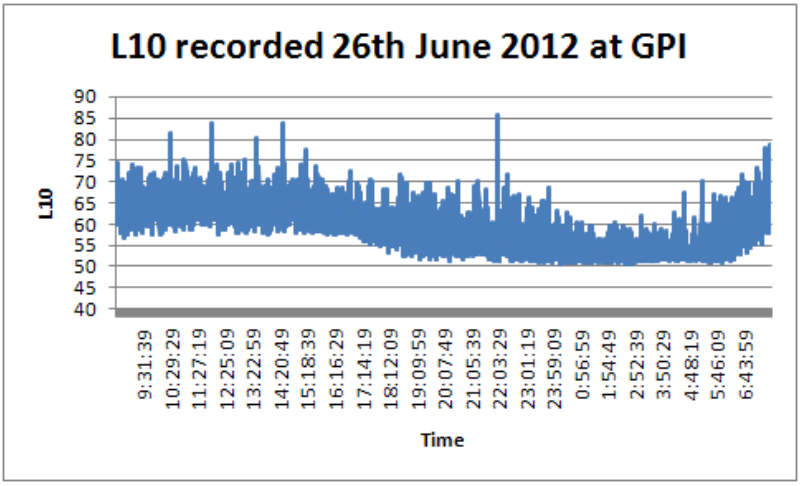
Barbados Port Inc.-26th June 2012

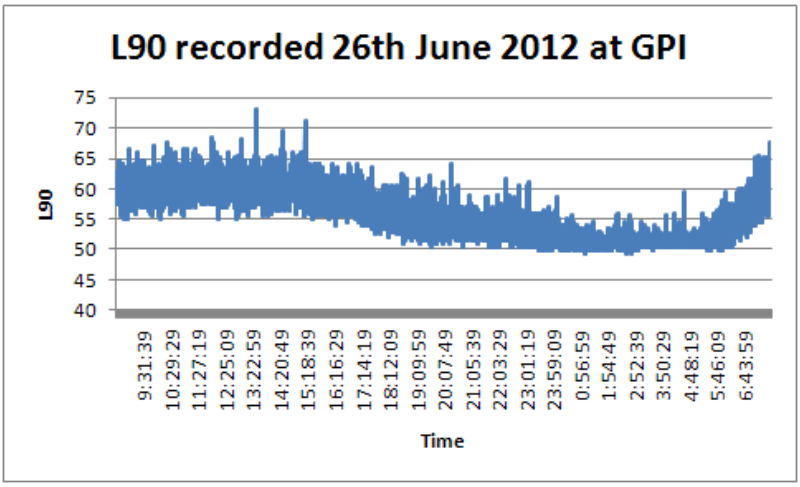
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/26/2012 8:33
Elapsed Time 0023:06:58
Pauses 0
Overload 0.0 %
MaxP 116.5 dB
MaxL 93.5 dB
MinL 49.2 dB
Leq 60.2 dB
SEL 109.5 dB
LEPd (Te= 7h30) 59.9 dB
L10 63.0 dB
L50 57.0 dB
L90 51.5 dB





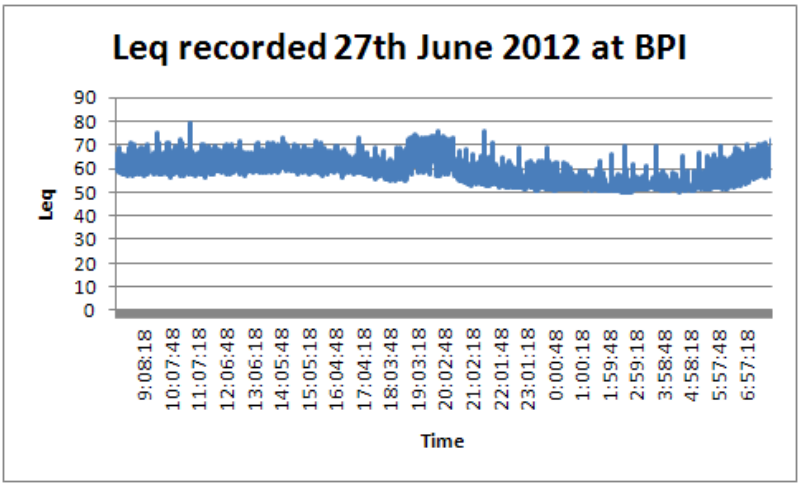


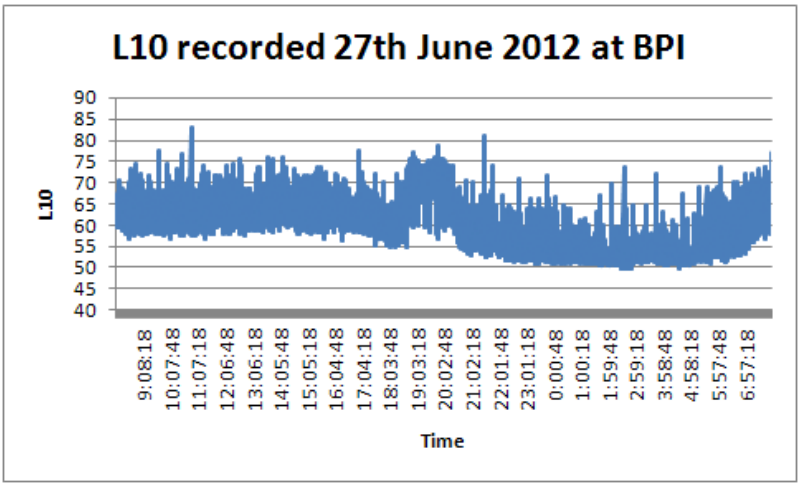
Barbados Port Inc.- 27th June 2012

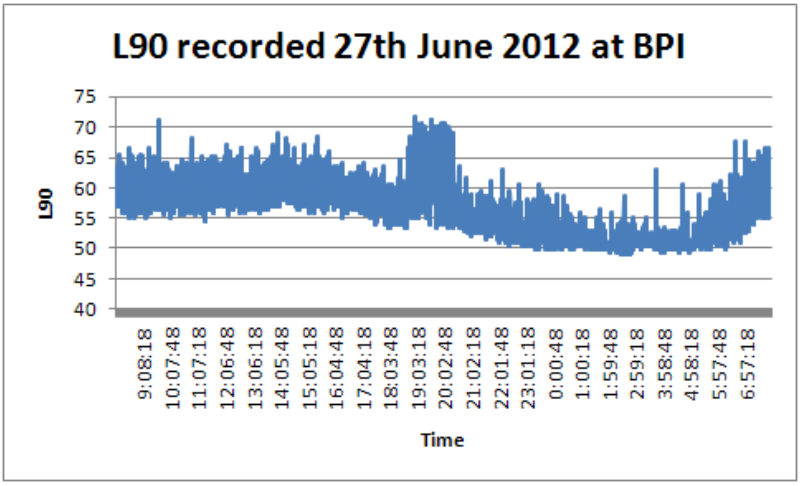
Brüel & Kjær
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

6/27/2012 8:08
Elapsed Time 0023:44:34
Pauses 0
Overload 0.0 %
MaxP 113.6 dB
MaxL 88.4 dB
MinL 48.7 dB
Leq 62.4 dB
SEL 111.7 dB
LEPd (Te= 7h30) 62.1 dB
L10 65.5 dB
L50 58.0 dB
L90 51.0 dB





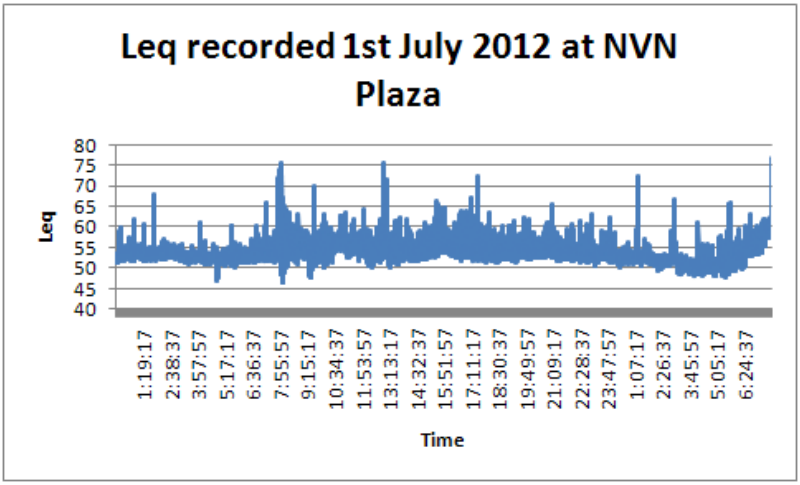


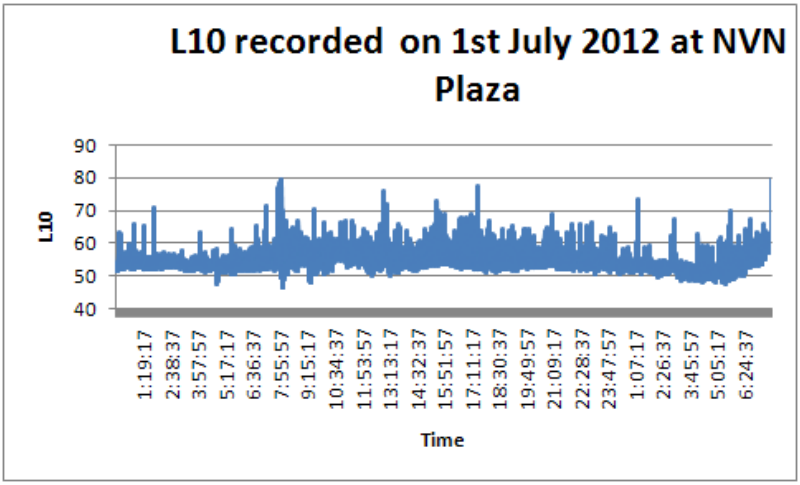
NVN Plaza- 1st July 2012

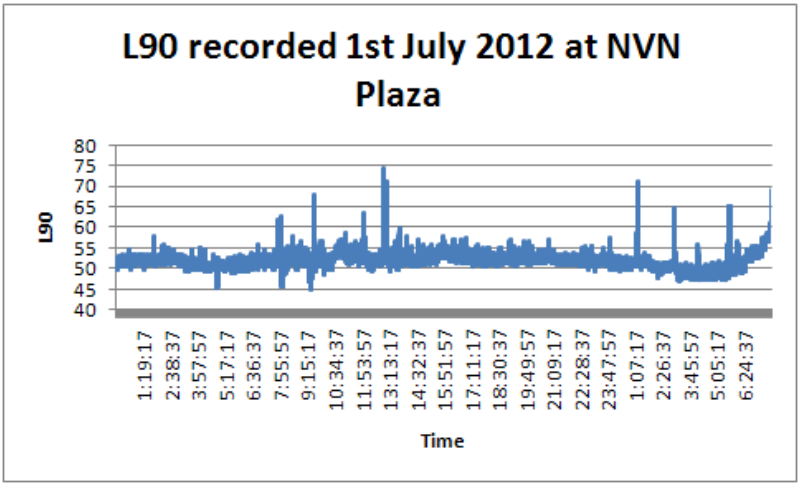
Bruel & Kjaer
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

7/1/2012 0:00
Elapsed Time 0031:42:28
Pauses 1
Overload 0.0 %
MaxP 111.7 dB
MaxL 83.1 dB
MinL 44.9 dB
Leq 55.3 dB
SEL 105.9 dB
LEPd (Te= 7h30) 55.0 dB
L10 55.5 dB
L50 53.0 dB
L90 50.5 dB





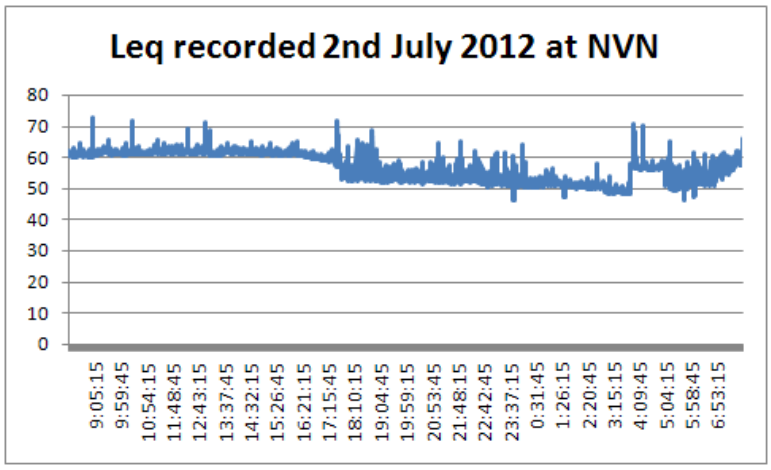


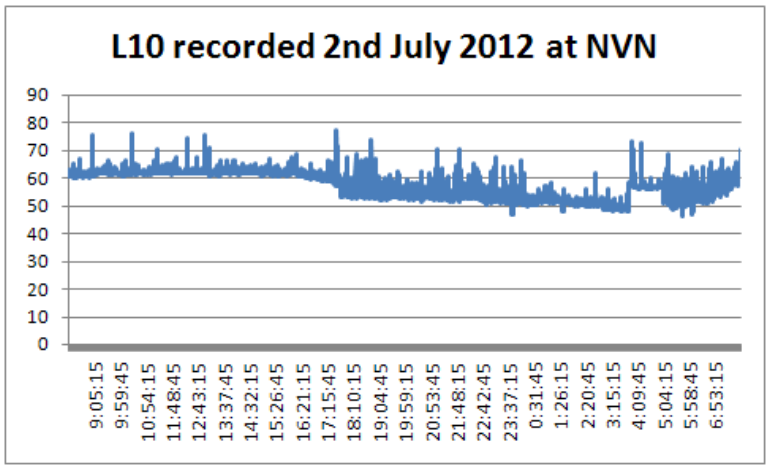
NVN – 2nd July 2012

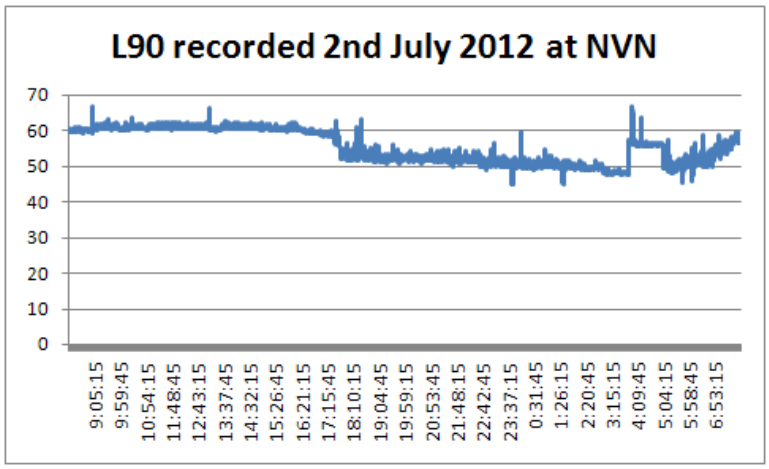
Bruel & Kjaer
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

7/2/2012 8:10
Elapsed Time 0023:34:56
Pauses 0
Overload 0.0 %
MaxP 108.9 dB
MaxL 83.2 dB
MinL 44.0 dB
Leq 58.6 dB
SEL 107.9 dB
LEPd (Te= 7h30) 58.3 dB
L10 61.5 dB
L50 55.5 dB
L90 50.5 dB





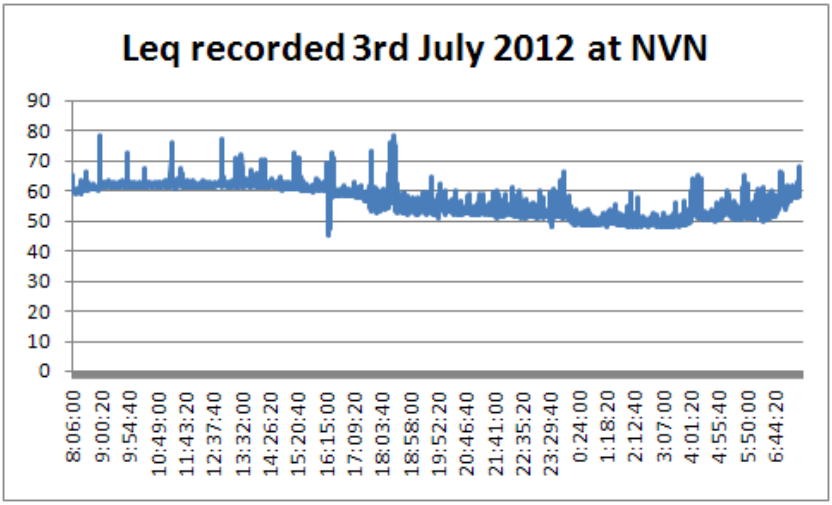


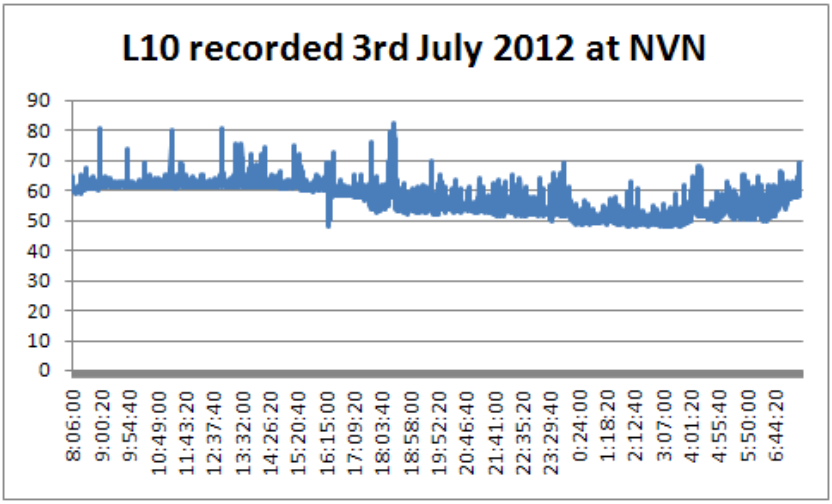
NVN -3rd July 2012

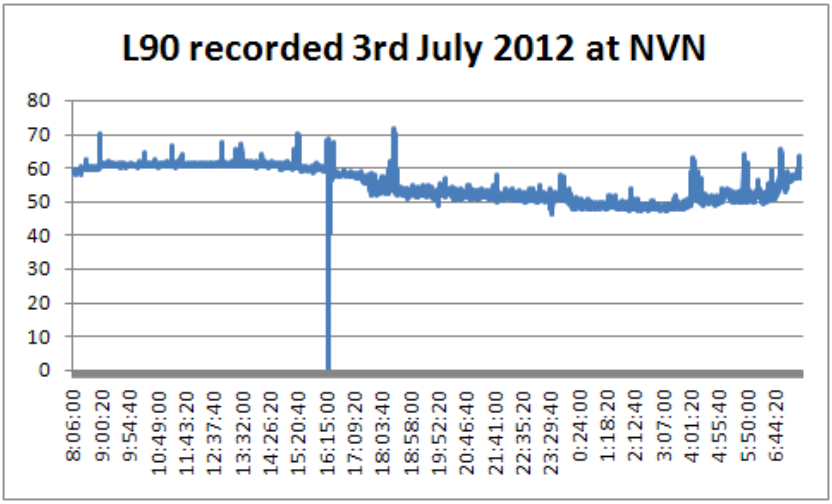
Bruel & Kjaer
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

7/3/2012 8:06
Elapsed Time 0023:31:59
Pauses 0
Overload 0.0 %
MaxP 113.8 dB
MaxL 90.7 dB
MinL ---.- dB
Leq 59.2 dB
SEL 108.5 dB
LEPd (Te= 7h30) 58.9 dB
L10 61.5 dB
L50 54.5 dB
L90 49.0 dB





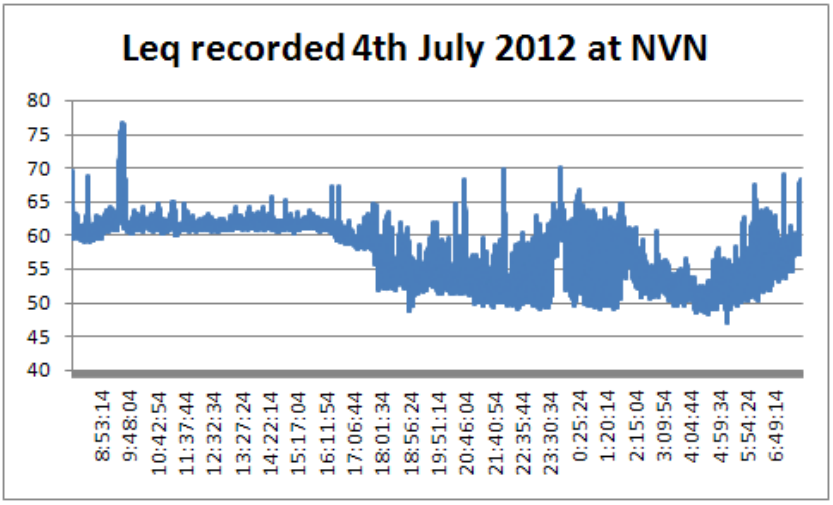


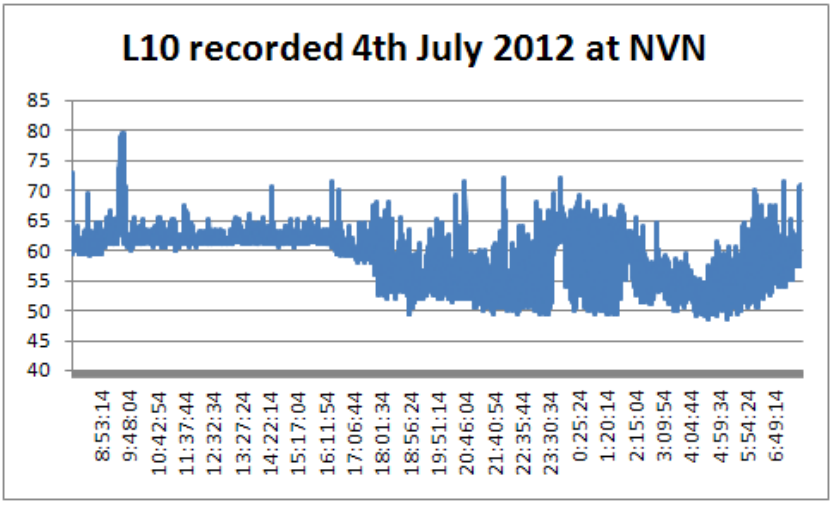
NVN- 4th July 2012

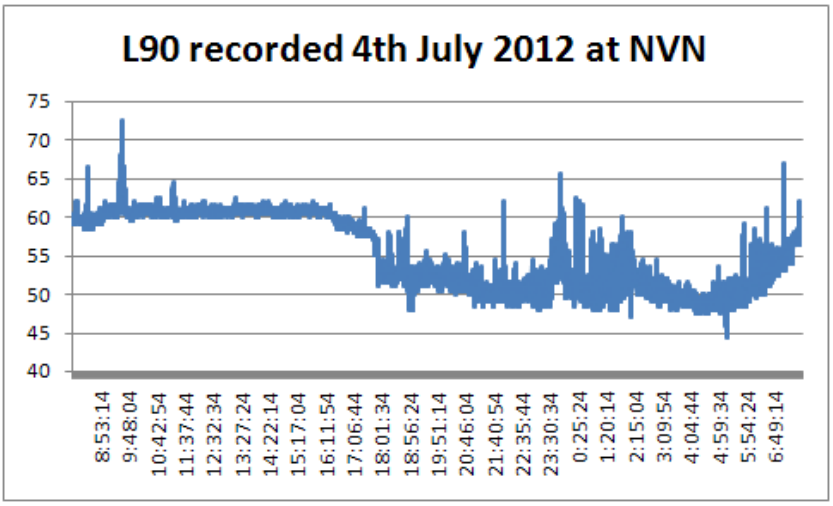
Bruel & Kjaer
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

7/4/2012 7:58
Elapsed Time 0023:44:10
Pauses 0
Overload 0.0 %
MaxP 111.3 dB
MaxL 83.9 dB
MinL 44.5 dB
Leq 59.7 dB
SEL 109.0 dB
LEPd (Te= 7h30) 59.4 dB
L10 61.5 dB
L50 57.0 dB
L90 50.0 dB





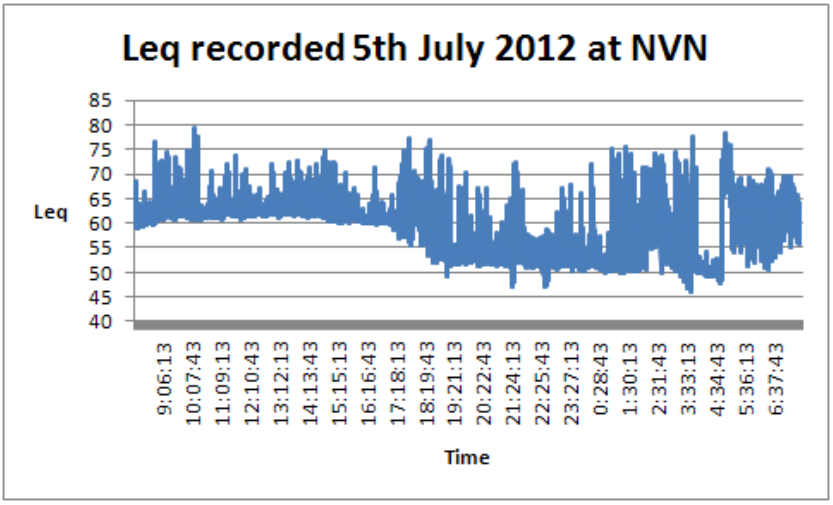


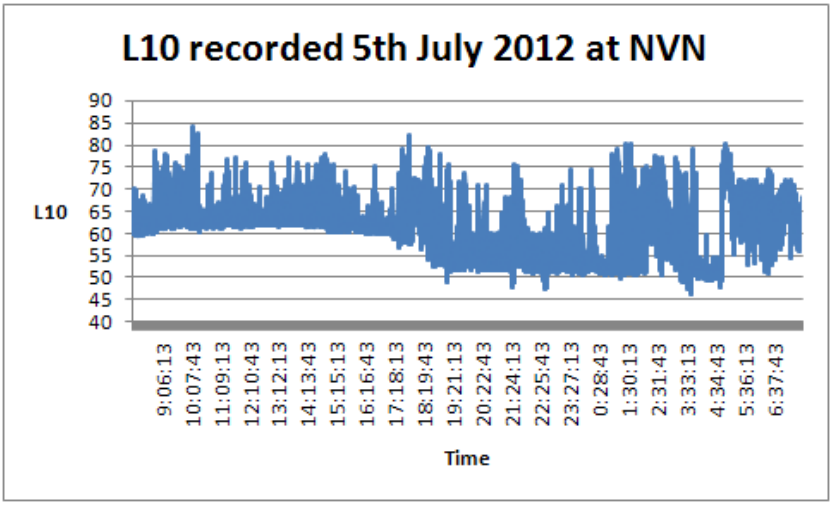
NVN- 5th July 2012

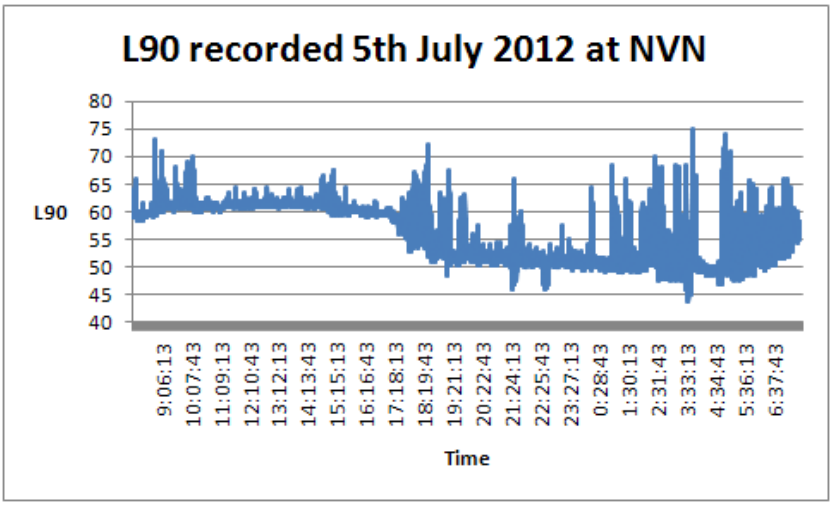
Bruel & Kjaer
SLM Type 2236
SETTINGS:

F 40-120 dB
RMS: A Peak: C
OVERALL RESULTS:

7/5/2012 8:04
Elapsed Time 0023:31:53
Pauses 0
Overload 0.0 %
MaxP 118.1 dB
MaxL 86.8 dB
MinL 43.9 dB
Leq 63.4 dB
SEL 112.7 dB
LEPd (Te= 7h30) 63.1 dB
L10 65.5 dB
L50 60.0 dB
L90 51.0 dB



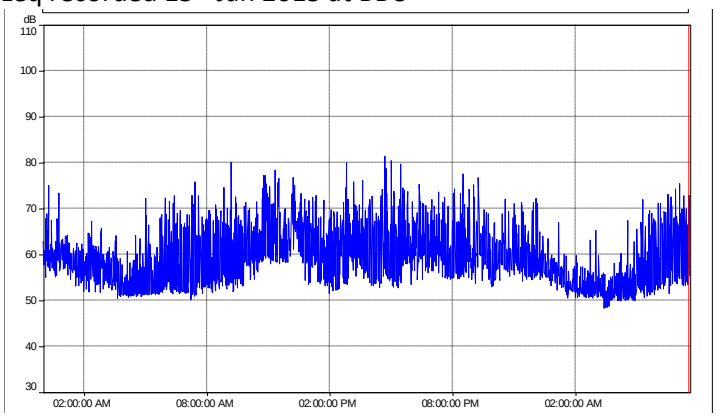




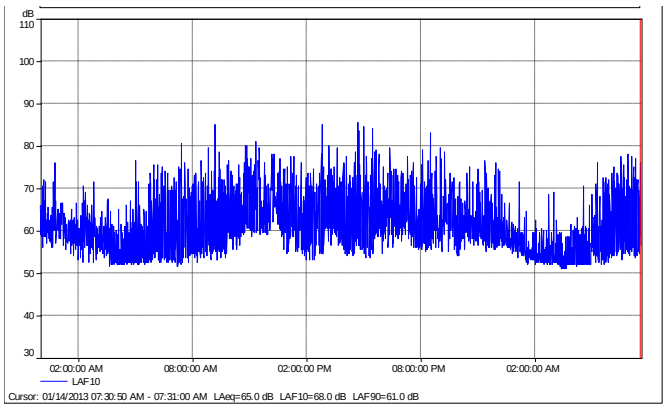
Berean Bible Church (BBC)-13th Jan 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0	61.9	73.2	64.1	57.8	52.1	92.7	37.9	110.2	0
Time	12:00:00 AM	7:36:10 AM	31:36:10										
Date	1/13/2013	1/14/2013											

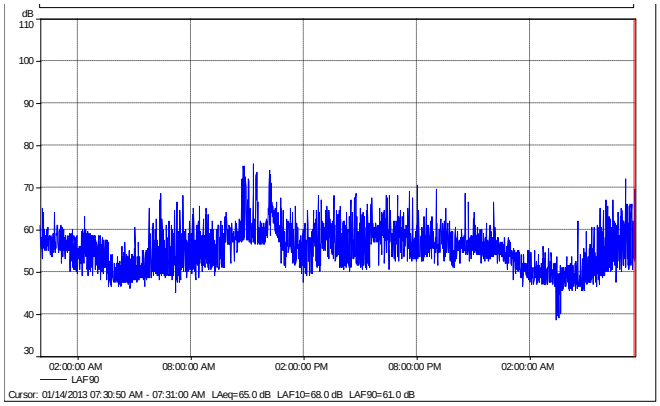
Leq recorded 13th Jan 2013 at BBC



L10 recorded 13th Jan 2013 at BBC



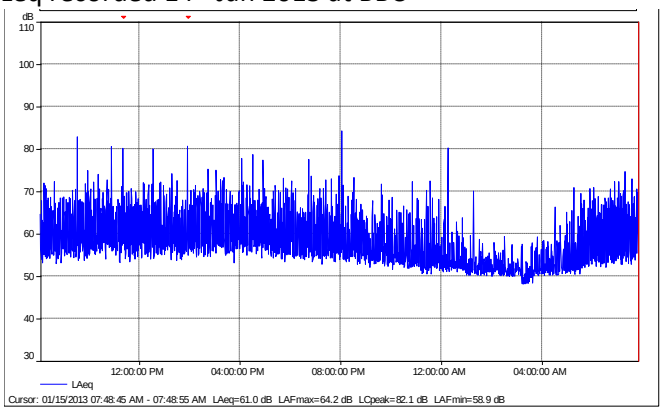
L90 recorded 13th Jan 2013 at BBC



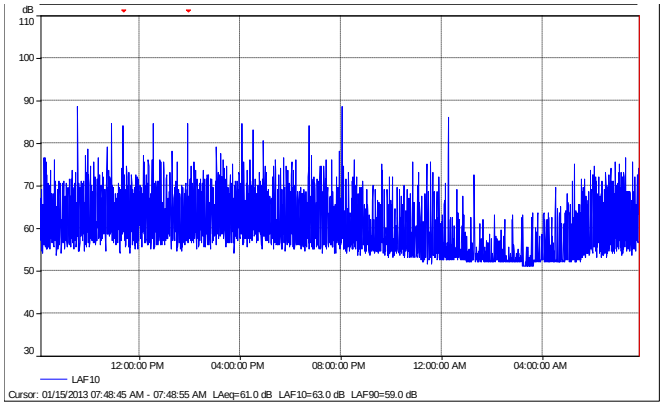
Berean Bible Church (BBC)-14th Jan 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0	61.2	70.5	64.3	57.2	51.5	94.1	36.4	116.5	0
Time	8:04:45 AM	7:48:48 AM	23:44:03										
Date	1/14/2013	1/15/2013											

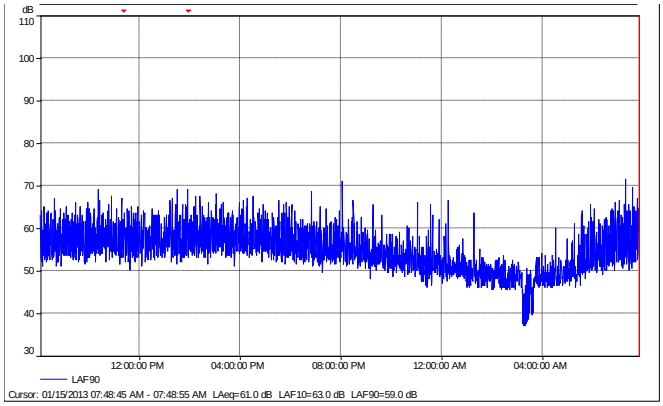
Leq recorded 14th Jan 2013 at BBC



L10 recorded 14th Jan 2013 at BBC



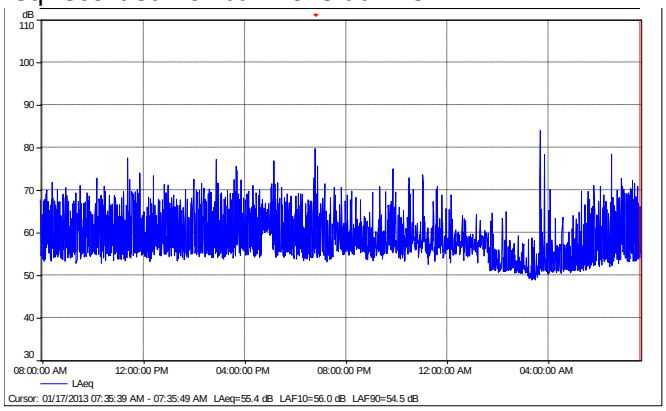
L90 recorded 14th Jan 2013 at BBC



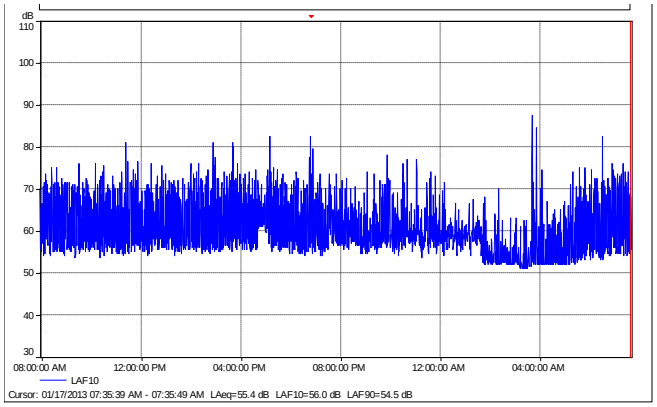
Berean Bible Church (BBC)-16th Jan 2013

	Start	End	Elapsed	Overload	LAeq	LA10	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0	60.7	69.6	63.8	57.5	52.3	93.4	38.3	115.2	0
Time	7:55:19 AM	7:39:31 AM	23:44:12										
Date	1/16/2013	1/17/2013											

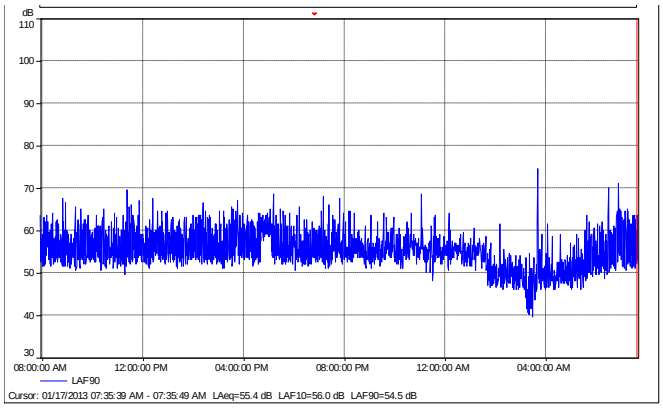
Leq recorded 16th Jan 2013 at BBC



L10 recorded 16th Jan 2013 at BBC



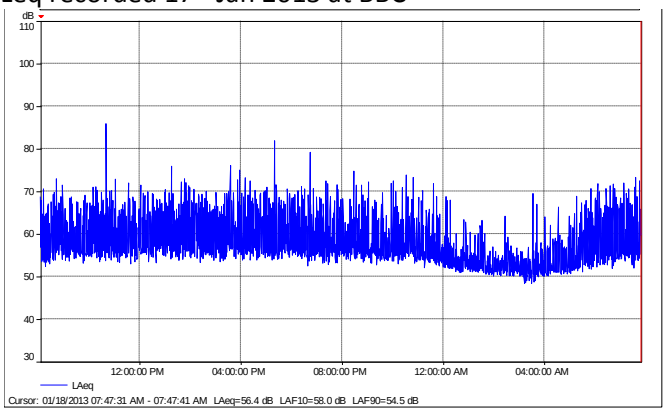
L90 recorded 16th Jan 2013 at BBC



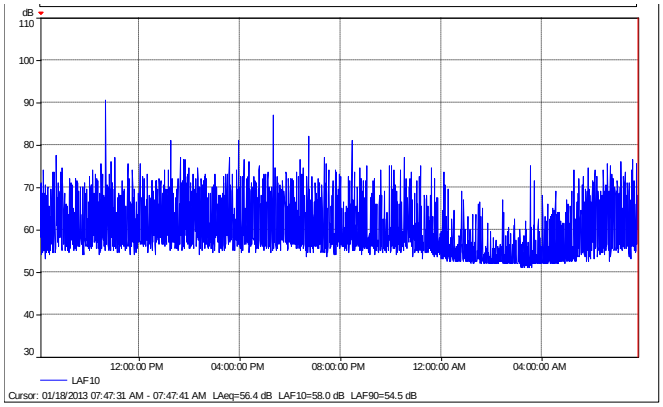
Berean Bible Church-17th January 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.	
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks	
Value				0	60.5	69.8	63.7	57.1	51.9	93.3	38	115.7	0	
Time	8:05:11 AM	7:49:22 AM	23:44:11											
Date	1/17/2013	1/18/2013												

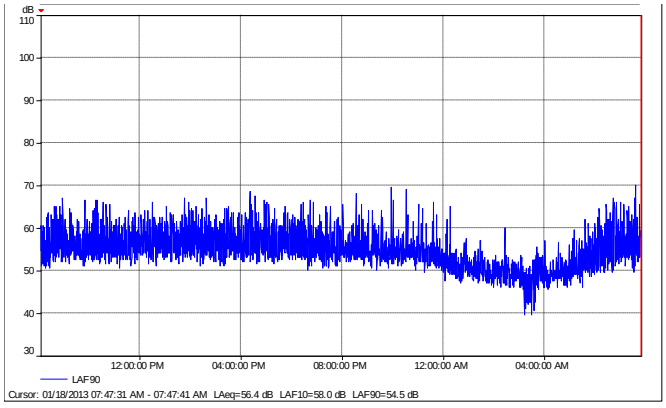
Leq recorded 17th Jan 2013 at BBC



L10 recorded 17th Jan 2013 at BBC



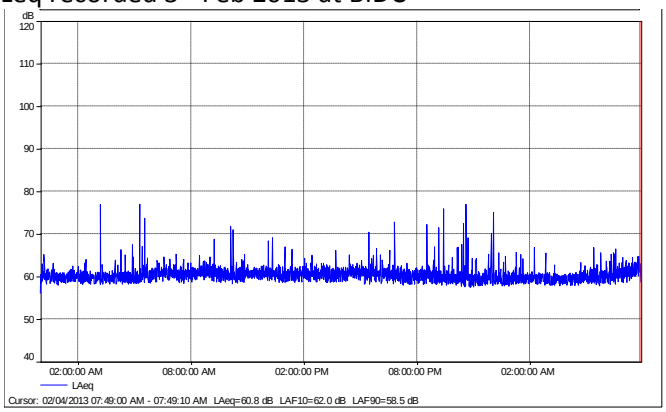
L90 recorded 17th Jan 2013 at BBC



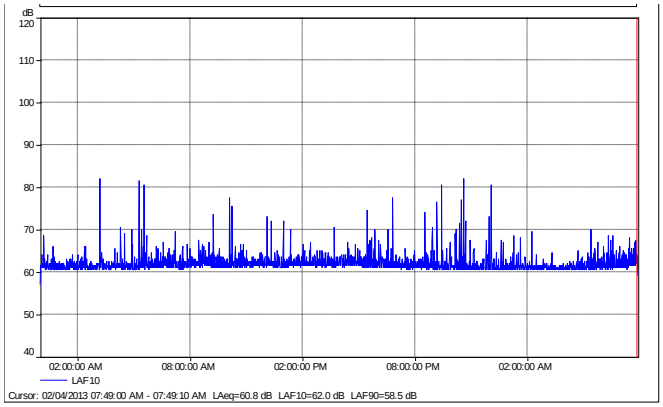
BIDC Small Business Centre- 3rd February, 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0	60.5	63.5	61.3	60.2	59.5	84.6	50.4	109.1	0
Time	12:00:00 AM	7:54:13 AM	7:54:13										
Date	2/3/2013	2/4/2013											

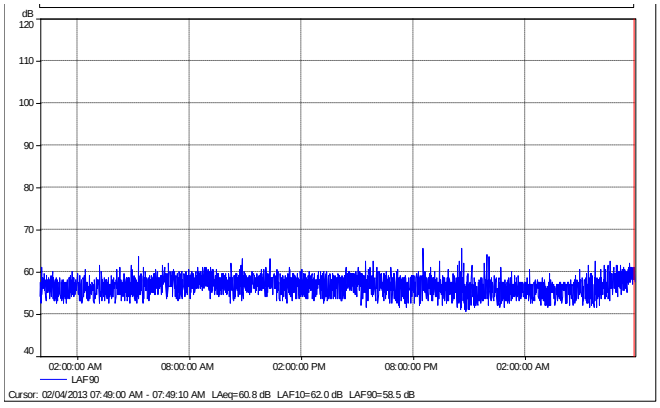
Leq recorded 3rd Feb 2013 at BIDC



L10 recorded 3rd Feb 2013 at BIDC



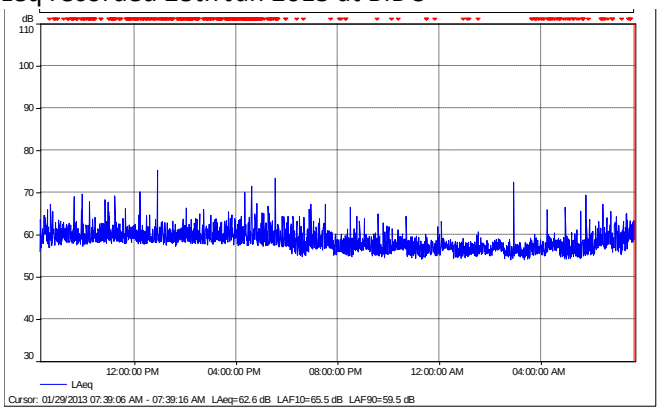
L90 recorded 3rd Feb 2013 at BIDC



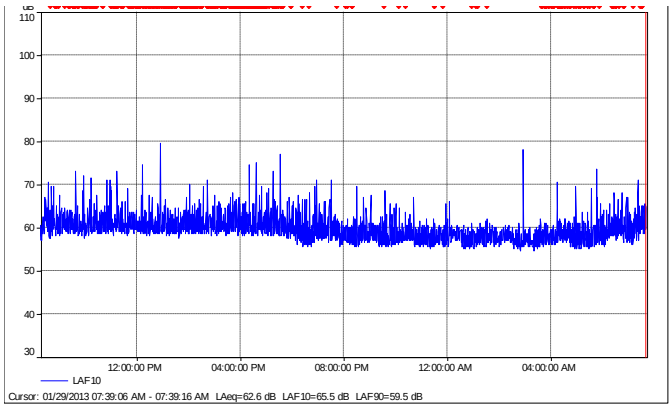
BIDC Small Business Centre- 28th January, 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0.02	58.8	63.9	60.6	58.3	55.8	83.6	50.8	112.9	0
Time	8:17:16 AM	7:43:06 AM	23:25:50										
Date	1/28/2013	1/29/2013											

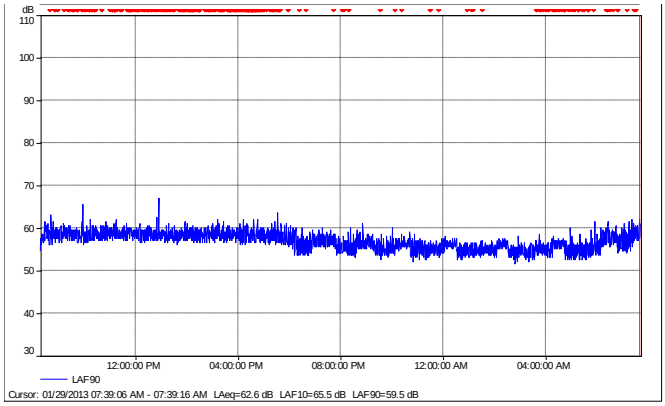
Leq recorded 28th Jan 2013 at BIDC



L10 recorded 28th Jan 2013 at BIDC



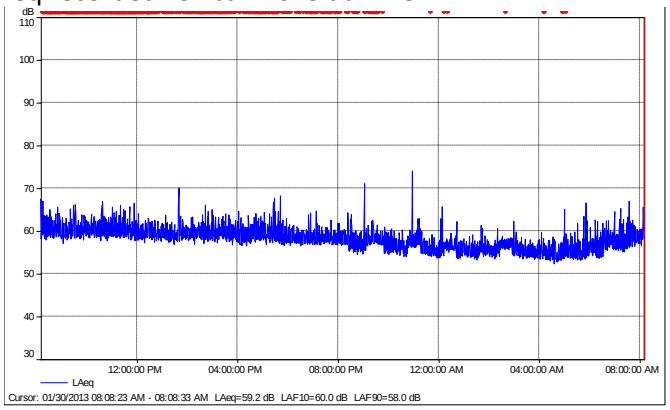
L90 recorded 28th Jan 2013 at BIDC



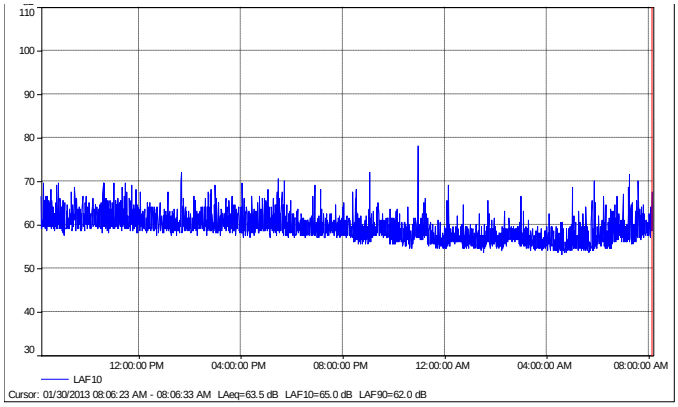
BIDC Small Business Centre- 29th January, 2013

	Start	End	Elapsed	Overload	LAeq	LA1	LA10	LA50	LA90	LAFmax	LAFmin	LCpeak	No.
	time	time	time	[%]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	[dB]	of Cpeaks
Value				0.07	58.5	63.4	60.6	58.1	54.8	87.1	49.7	112.8	0
Time	8:10:23 AM	8:10:18 AM	23:59:55										
Date	1/29/2013	1/30/2013											

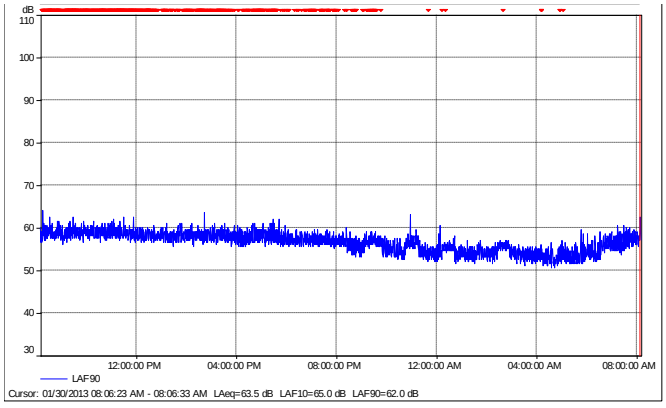
Leq recorded 29th Jan 2013 at BIDC



L10 recorded 29th Jan 2013 at BIDC

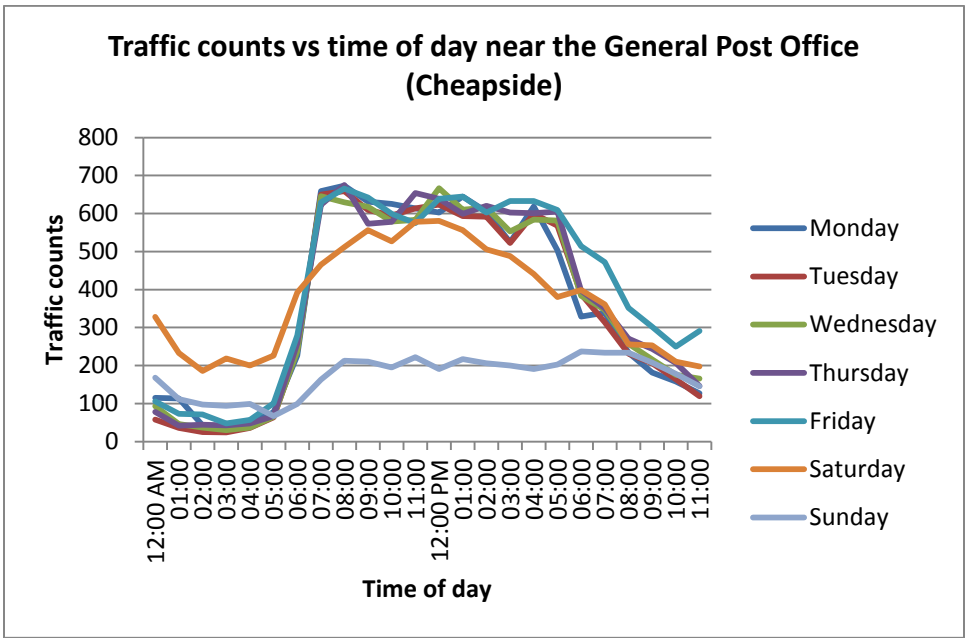


L90 recorded 29th Jan 2013 at BIDC



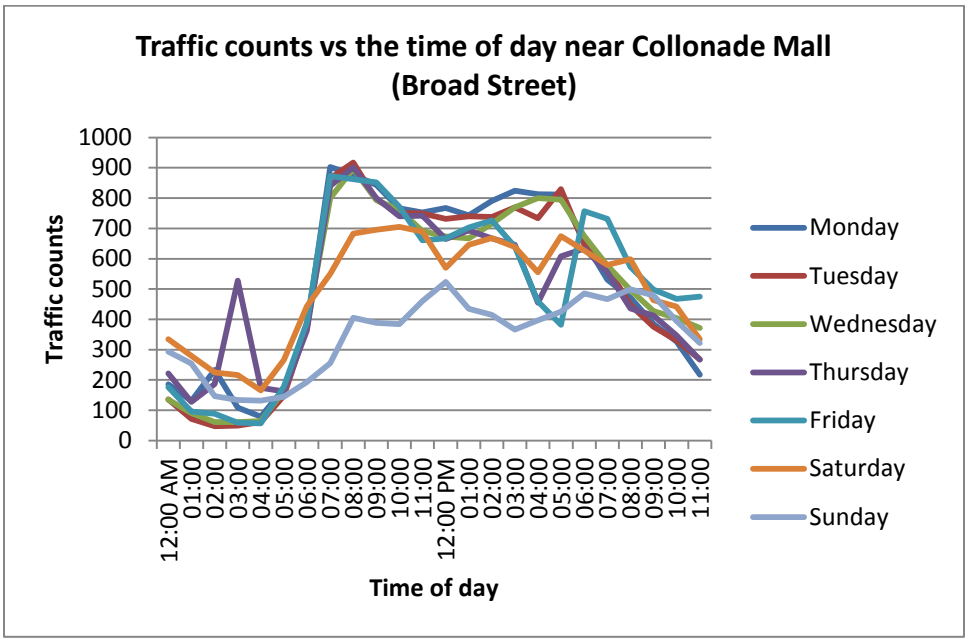
Appendix 6: Road Traffic Data

General Post Office (18th -24th June, 2012)



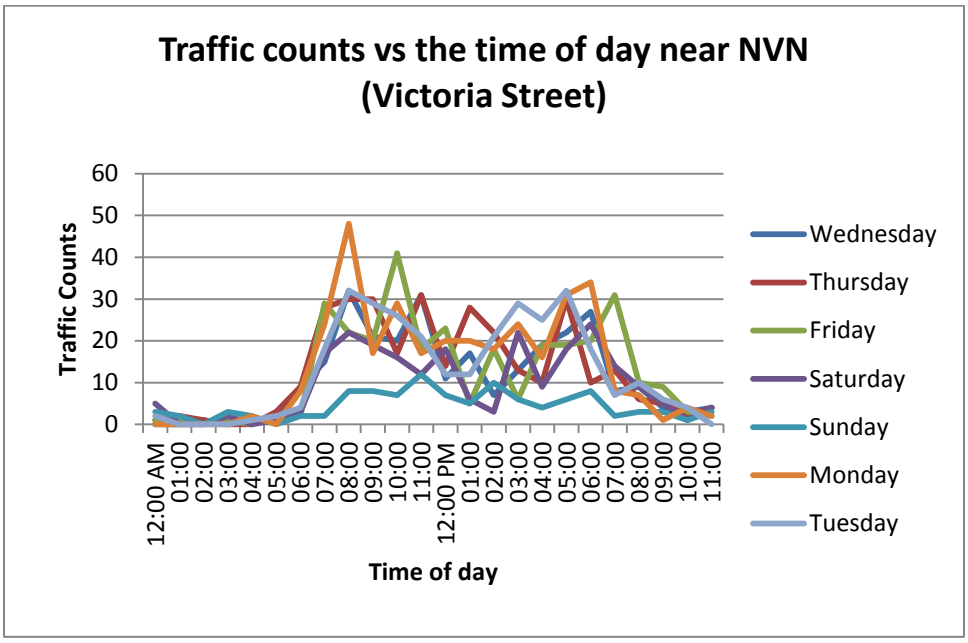
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12:00 AM	115	58	93	78	106	328	168
01:00	113	36	46	42	73	233	112
02:00	43	25	37	44	71	186	97
03:00	36	24	30	43	48	219	94
04:00	49	36	37	48	57	200	99
05:00	77	64	65	67	101	226	67
06:00	226	241	238	258	279	392	99
07:00	659	650	646	623	630	465	163
08:00	673	659	630	675	666	512	213
09:00	631	609	618	573	642	556	210
10:00	625	595	579	578	599	527	195
11:00	614	614	583	654	575	578	222
12:00 PM	603	624	667	639	639	581	191
01:00	645	593	610	599	645	556	217
02:00	605	592	615	620	603	506	206
03:00	524	523	553	603	633	488	200
04:00	619	599	584	601	633	441	191
05:00	503	568	582	605	609	380	203
06:00	329	388	384	397	514	399	237
07:00	339	314	347	351	472	361	234
08:00	234	231	257	271	352	256	234
09:00	182	206	216	244	302	253	208
10:00	158	164	176	207	250	210	178
11:00	127	119	166	146	291	198	145

Collonade Mall (16th -22nd July, 2012)



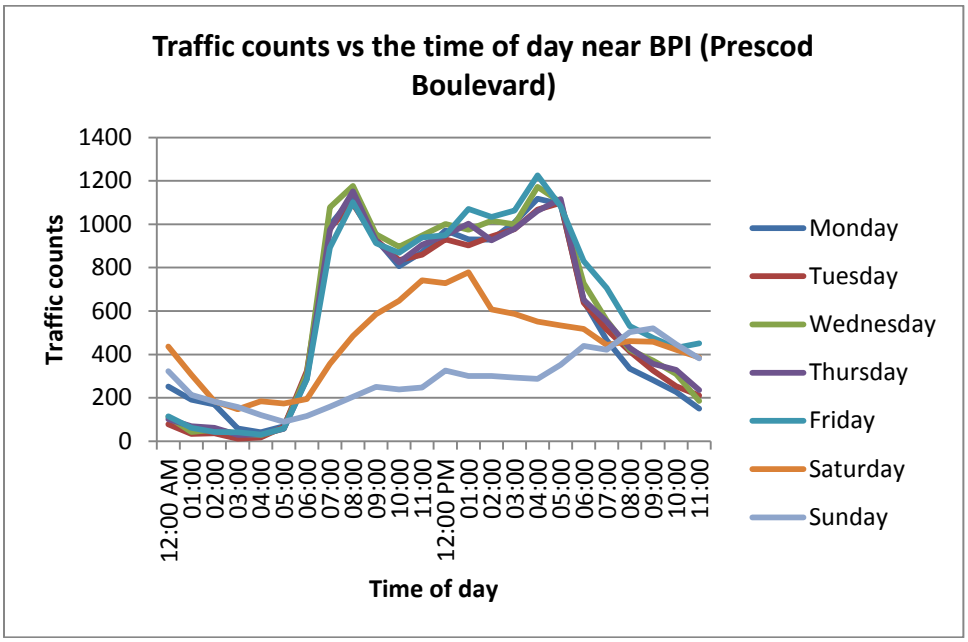
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12:00 AM	186	136	135	222	176	335	293
01:00	131	72	91	128	96	280	254
02:00	233	47	61	187	89	225	147
03:00	109	49	61	528	59	216	134
04:00	79	61	64	174	57	166	132
05:00	171	148	165	163	178	266	144
06:00	374	376	380	363	391	443	193
07:00	903	866	800	840	873	550	255
08:00	877	917	897	902	862	683	405
09:00	843	795	794	800	852	696	388
10:00	766	752	761	740	772	705	384
11:00	753	749	691	742	661	689	460
12:00 PM	767	732	673	665	667	570	524
01:00	743	740	667	693	703	646	435
02:00	791	738	716	667	726	668	415
03:00	824	770	770	646	640	639	366
04:00	813	734	800	455	459	555	397
05:00	812	830	795	608	382	674	425
06:00	657	647	675	633	757	627	486
07:00	531	571	577	556	731	580	466
08:00	472	447	497	436	573	599	499
09:00	385	376	427	413	498	463	479
10:00	327	330	404	347	468	442	395
11:00	217	268	372	267	475	335	322

NVN Plaza (4th-10th July, 2012)



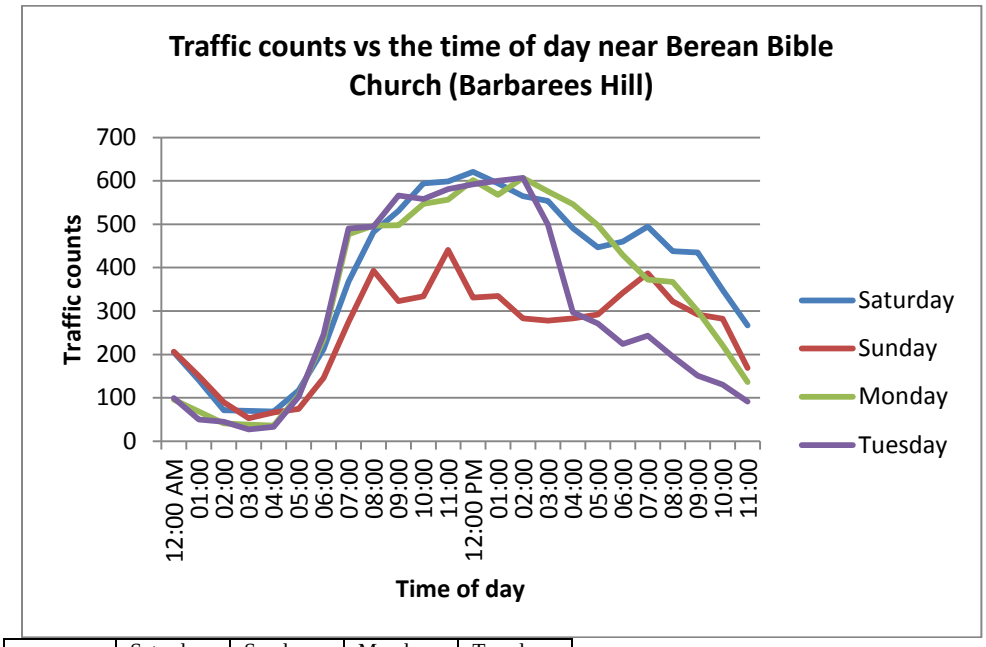
	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday
12:00 AM	0	1	1	5	3	0	2
01:00	0	2	1	0	2	0	0
02:00	1	1	0	0	0	0	0
03:00	0	0	1	2	3	0	0
04:00	1	0	0	0	2	2	1
05:00	1	3	2	1	0	0	2
06:00	9	9	2	3	2	8	4
07:00	15	28	29	17	2	24	18
08:00	32	30	22	22	8	48	32
09:00	21	30	20	19	8	17	29
10:00	20	17	41	16	7	29	26
11:00	31	31	18	12	12	17	21
12:00 PM	11	14	23	18	7	20	12
01:00	17	28	5	6	5	20	12
02:00	7	22	18	3	10	18	21
03:00	13	13	6	22	6	24	29
04:00	19	10	19	9	4	16	25
05:00	22	30	19	18	6	31	32
06:00	27	10	20	24	8	34	18
07:00	8	13	31	14	2	8	7
08:00	9	6	10	9	3	7	10
09:00	4	5	9	5	3	1	6
10:00	3	2	3	1	1	4	4
11:00	4	4	2	4	3	2	0

Barbados Port Authority Inc. (25th June, 2012-1st July, 2012)



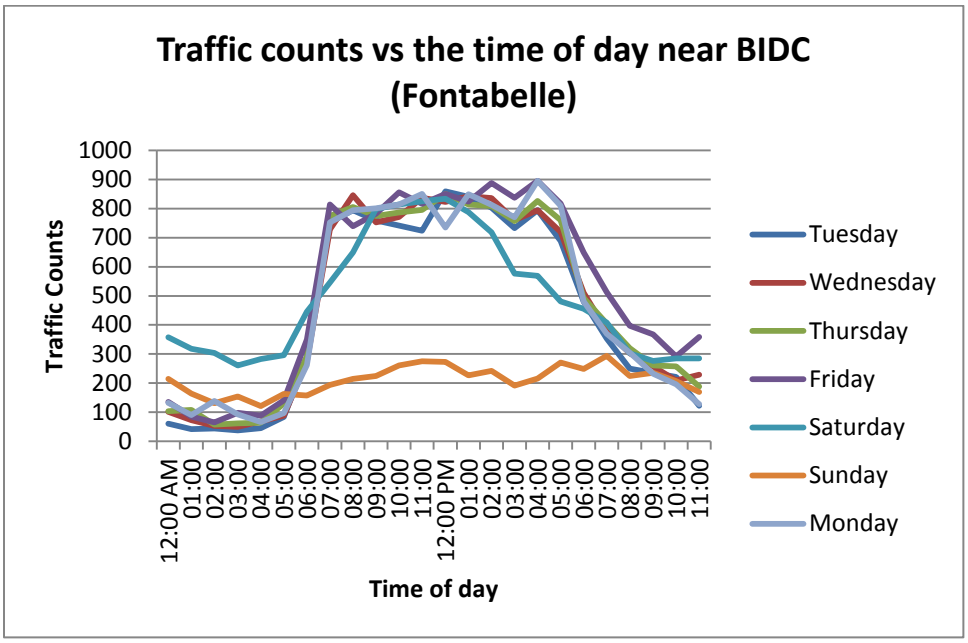
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12:00 AM	252	78	112	102	114	436	322
01:00	192	33	43	69	61	307	214
02:00	169	36	52	62	43	184	183
03:00	59	11	35	29	41	147	158
04:00	41	17	27	31	31	184	121
05:00	69	66	59	57	59	174	89
06:00	302	324	311	289	286	194	116
07:00	996	983	1078	975	892	357	159
08:00	1127	1094	1177	1151	1102	485	204
09:00	932	929	954	924	913	585	251
10:00	807	835	896	824	868	647	239
11:00	872	859	948	905	939	742	247
12:00 PM	972	930	1001	949	950	729	326
01:00	931	902	974	1003	1071	779	300
02:00	929	944	1016	926	1034	608	301
03:00	1008	977	1000	979	1063	586	293
04:00	1118	1068	1172	1061	1226	551	287
05:00	1093	1098	1101	1116	1083	533	352
06:00	647	638	729	651	830	518	439
07:00	465	514	557	551	706	444	421
08:00	335	414	422	430	531	461	503
09:00	282	326	371	357	476	458	520
10:00	226	253	310	329	431	422	446
11:00	150	210	186	236	451	386	382

Berean Bible Church (14th -17th July, 2012)



	Saturday	Sunday	Monday	Tuesday
12:00 AM	205	206	96	99
01:00	141	150	68	50
02:00	71	90	41	45
03:00	70	53	38	27
04:00	68	66	36	33
05:00	117	74	106	102
06:00	212	146	235	246
07:00	368	275	477	490
08:00	482	393	497	495
09:00	531	323	498	566
10:00	594	334	547	558
11:00	599	441	557	581
12:00 PM	621	331	602	592
01:00	594	335	568	600
02:00	565	283	607	607
03:00	554	278	576	499
04:00	491	283	546	297
05:00	447	292	498	271
06:00	460	342	429	224
07:00	495	387	372	243
08:00	438	322	367	195
09:00	435	292	300	151
10:00	349	282	221	130
11:00	267	169	136	91

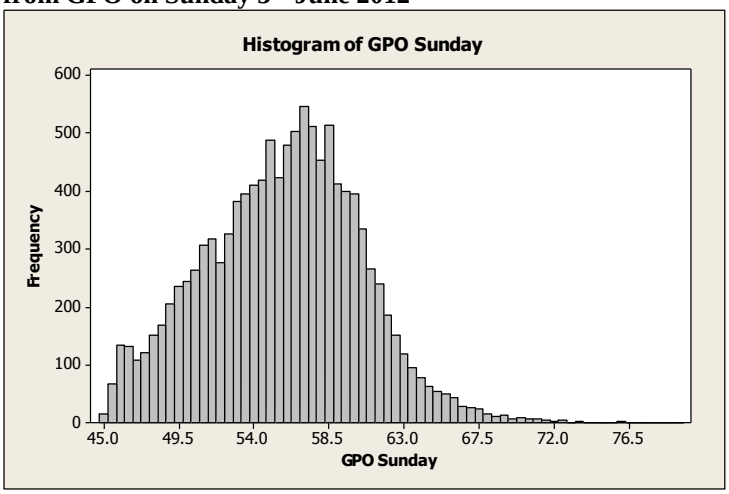
BIDC Small Business Centre (24th -30th July 2012)

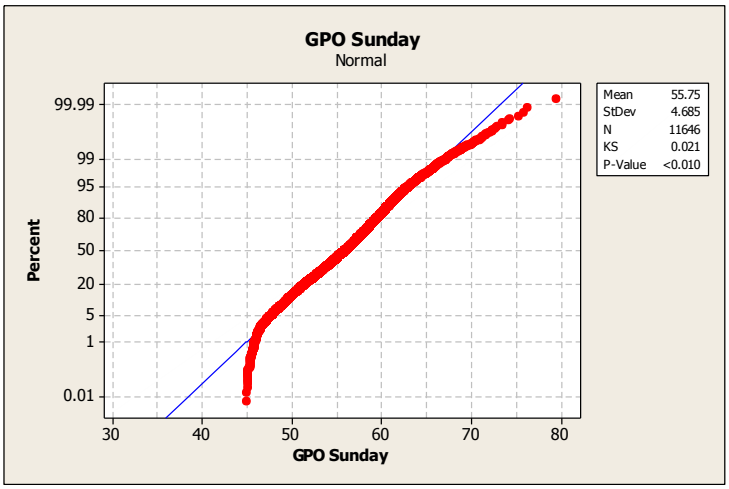


	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday
12:00 AM	60	101	103	135	357	214	132
01:00	42	72	108	84	318	164	90
02:00	44	52	57	65	303	131	138
03:00	37	49	61	98	260	154	92
04:00	45	68	63	88	283	121	66
05:00	83	88	129	141	296	163	96
06:00	289	274	291	350	446	157	262
07:00	753	729	775	814	546	193	753
08:00	795	846	806	740	649	214	794
09:00	759	753	775	782	799	224	801
10:00	742	771	787	856	814	260	814
11:00	724	837	796	817	825	275	851
12:00 PM	860	823	851	851	834	273	735
01:00	841	843	814	824	788	226	850
02:00	803	836	809	888	719	242	813
03:00	733	760	757	837	576	191	770
04:00	794	794	826	896	569	215	896
05:00	689	720	760	818	481	271	810
06:00	480	510	493	649	455	248	481
07:00	353	380	405	513	408	294	370
08:00	250	302	320	397	302	224	305
09:00	235	257	261	367	276	235	232
10:00	221	209	257	291	285	207	196
11:00	122	229	188	358	285	169	127

Appendix 7: Normality Tests on Data Collected from Each Site

Figure 20: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from GPO on Sunday 3rd June 2012





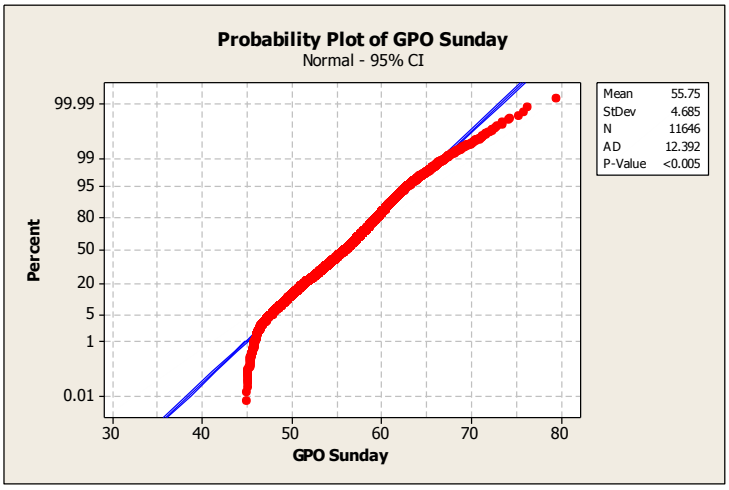
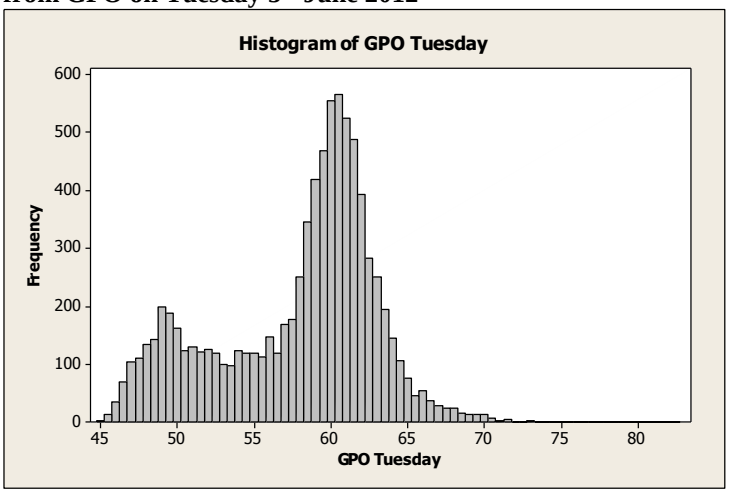
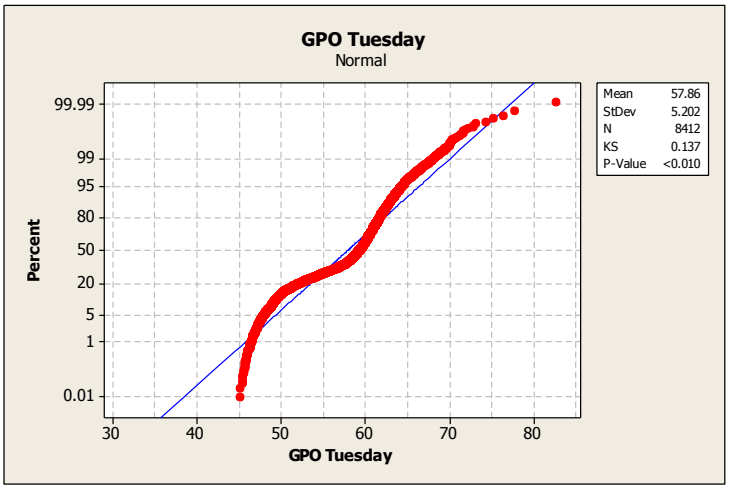


Figure 21: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from GPO on Tuesday 5th June 2012





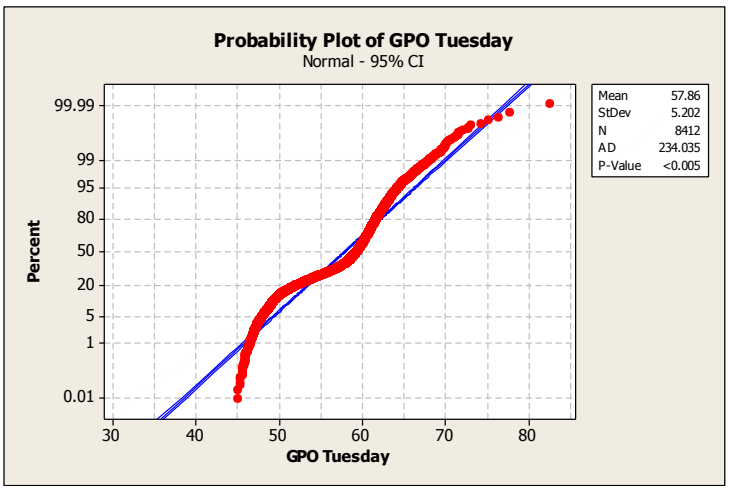
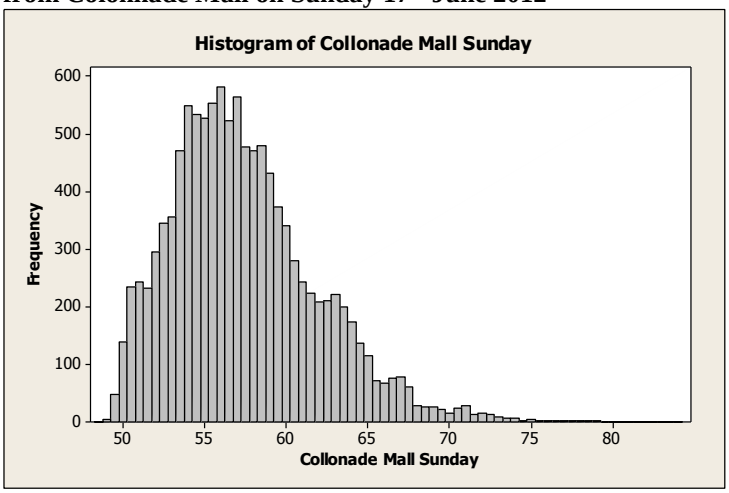
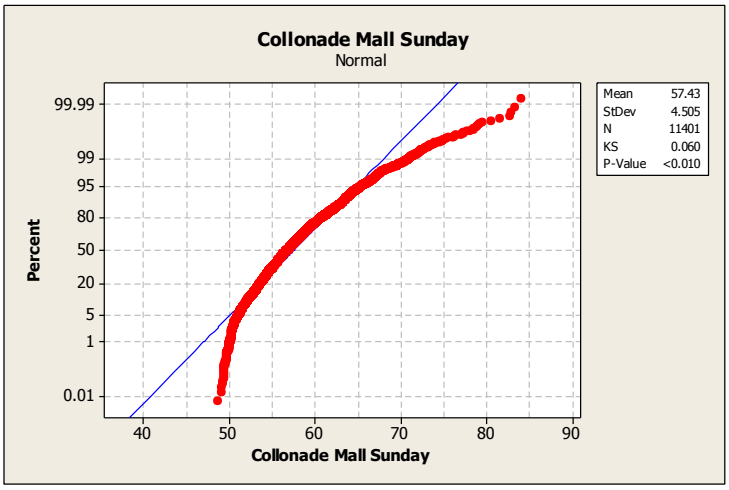


Figure 22: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from Colonnade Mall on Sunday 17th June 2012





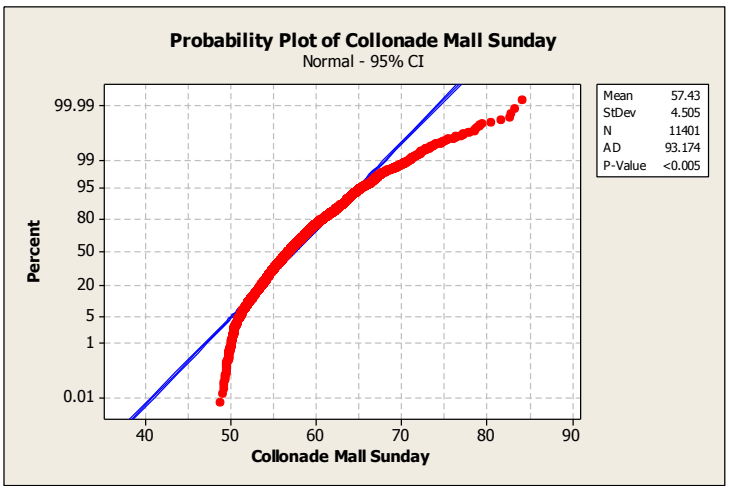
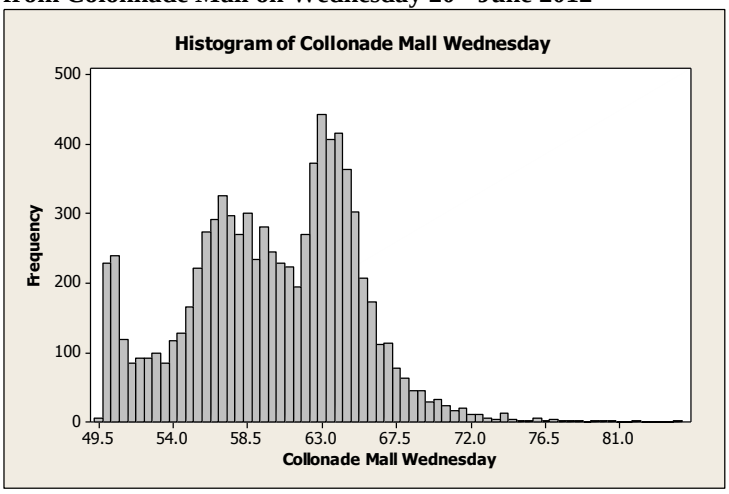
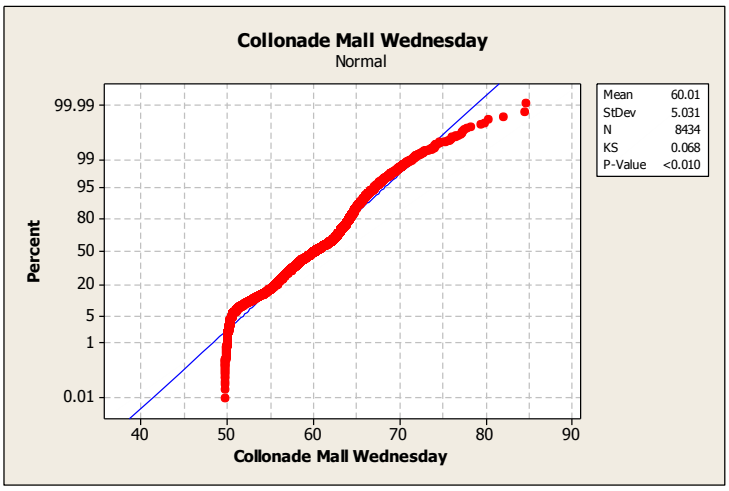


Figure 23: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from Colonnade Mall on Wednesday 20th June 2012





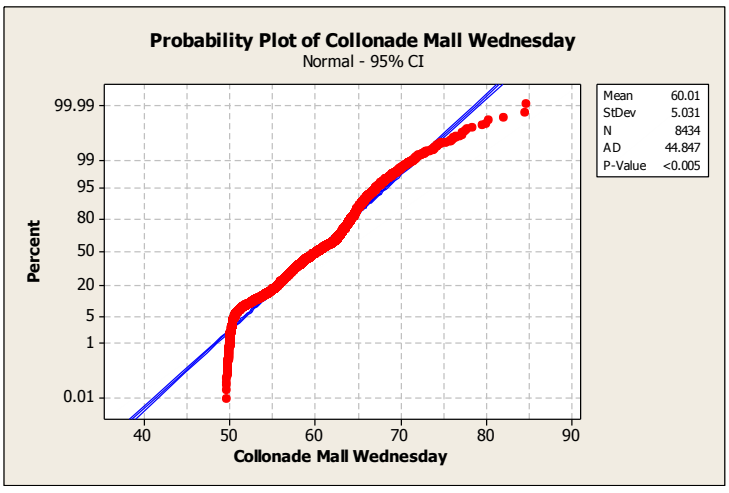
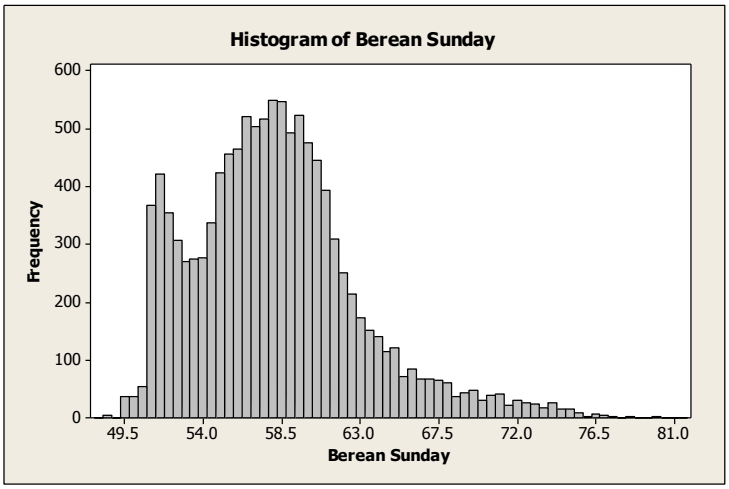
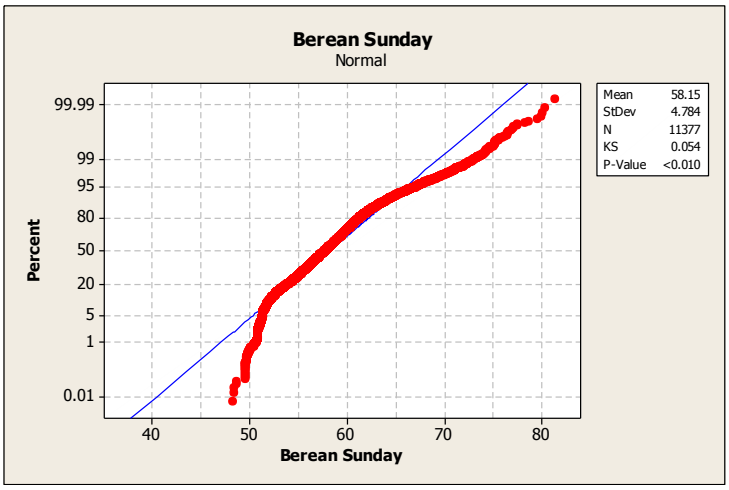


Figure 24: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from Berean Bible Church on Sunday 13th Jan 2013





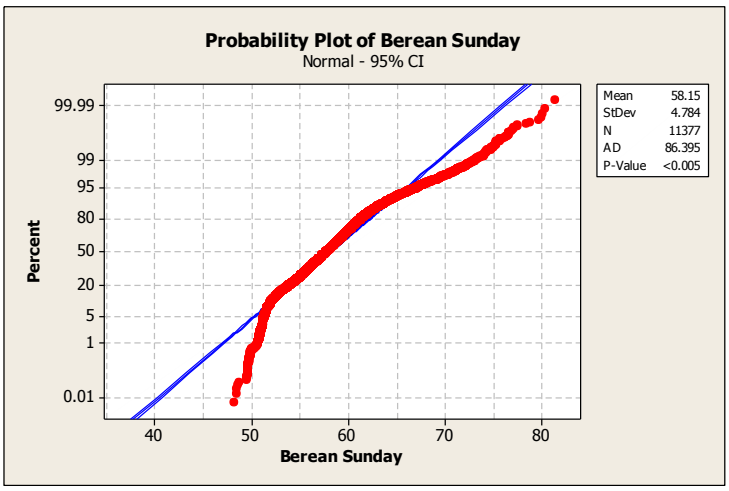
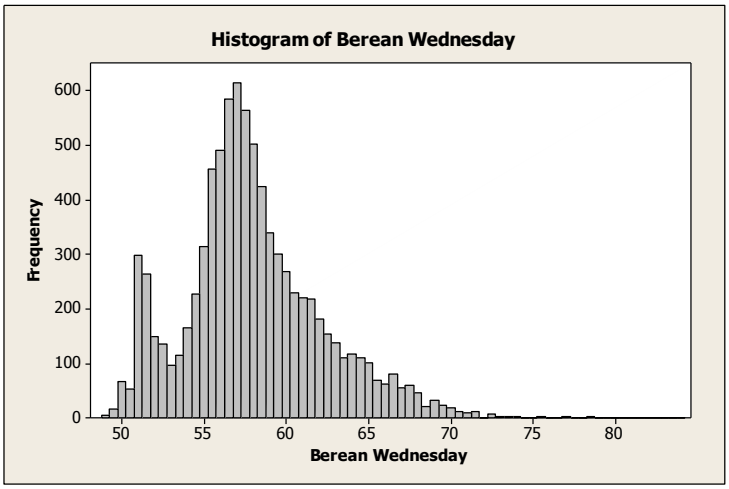
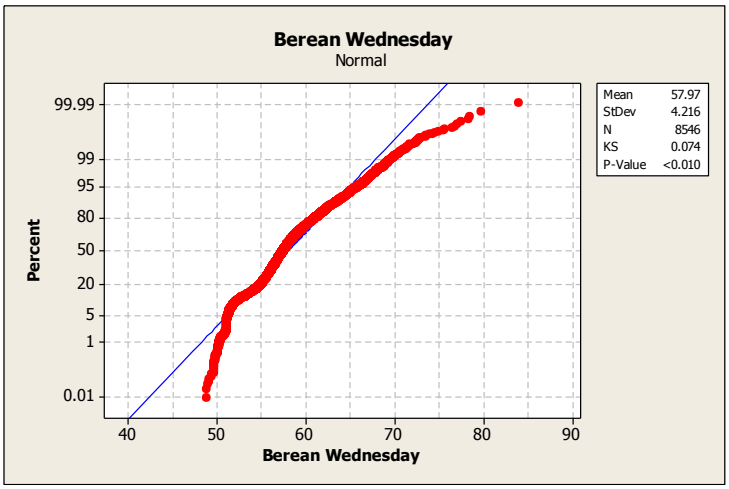


Figure 25: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from Berean Bible Church on Wednesday 16th Jan 2013





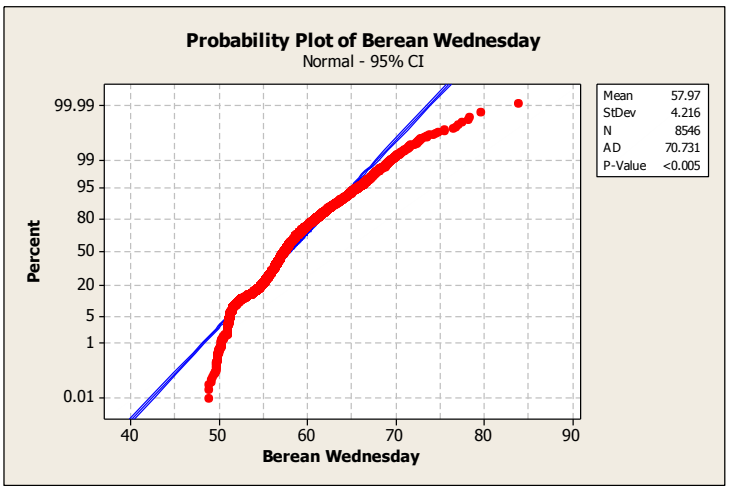
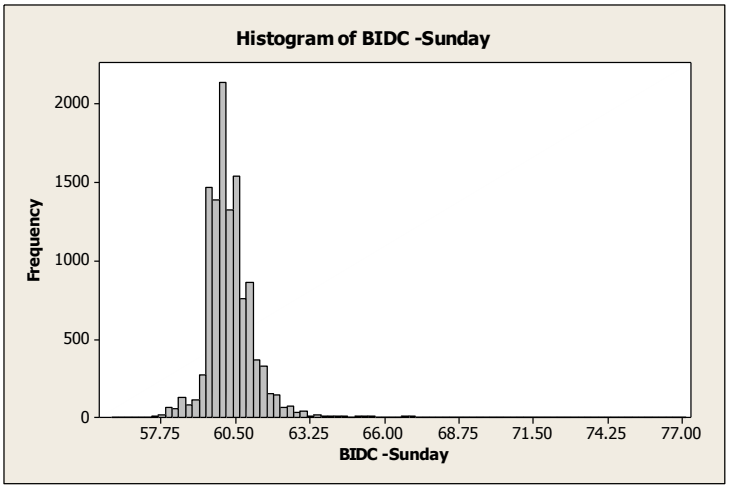
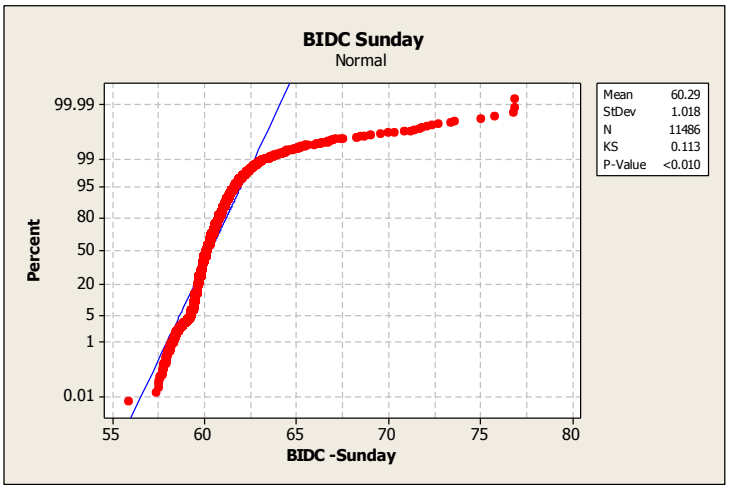


Figure 26: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from BIDC Small Business Centre on Sunday 3rd February 2013





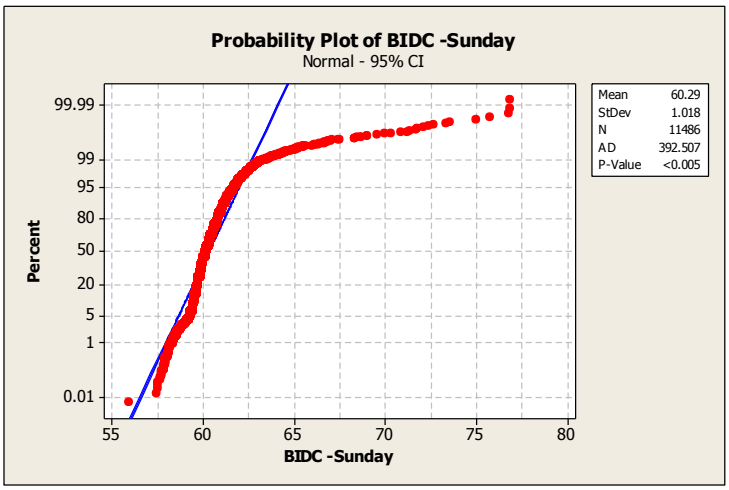
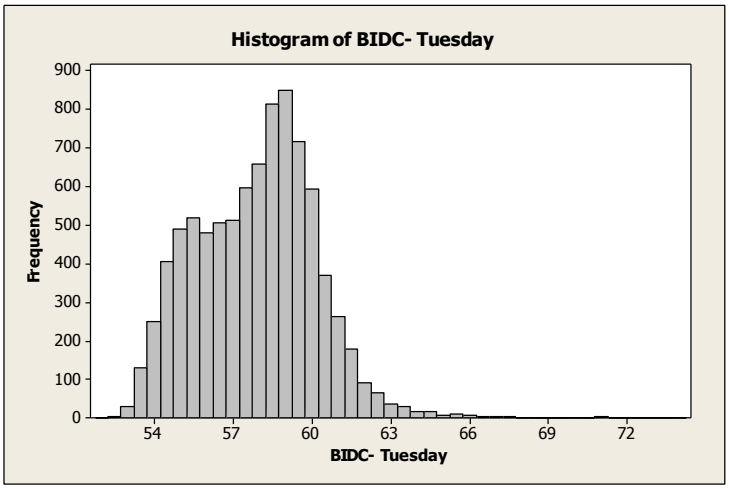
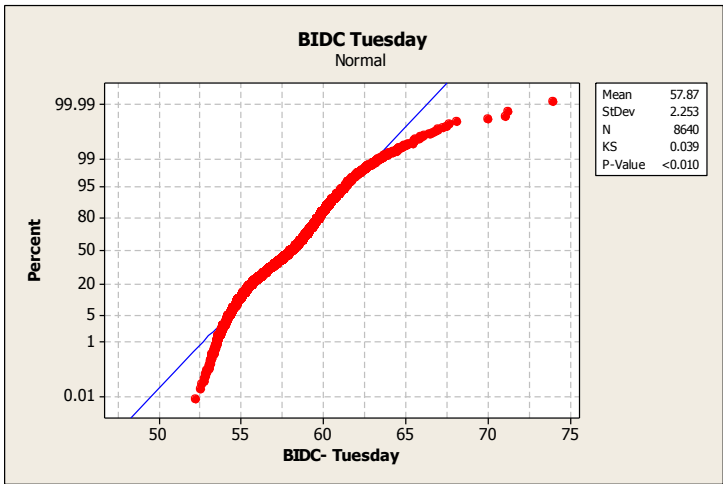
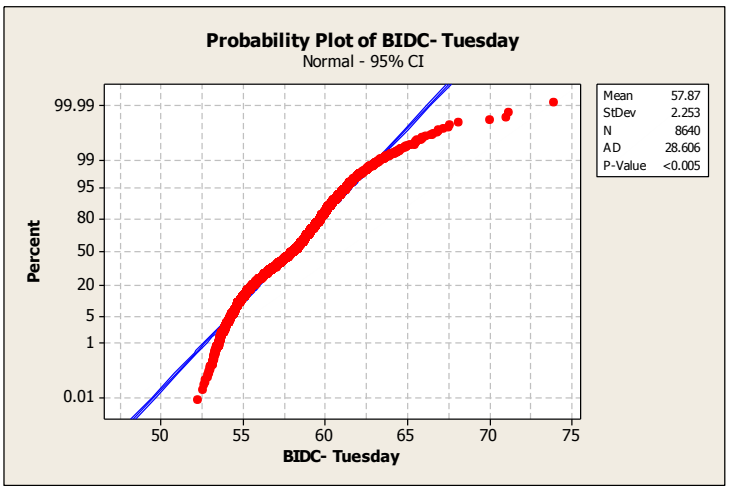


Figure 27: Histogram, Kolmogorov–Smirnov (KS) statistic and probability plots of sound levels collected from BIDC Small Business Centre on Tuesday 29th Jan 2013







Appendix 8: Contact Persons for the various monitoring sites

Location	Contact Information
BIDC Small Business Centre	Mr. Kenrick Hoyte: 426-2300 Mr. Sam Harrison: 427-5350, 234-4077 sharrison@bidc.org
Barbados Port Authority	Mr. Leacock: 826-8885 Mr. Gaskin: 826-5892 Mr. Junior Ince: 240-6199 434-6100 10.1.1
General Post Office	Mr. A. Jones (436-4800, ext 3234) Mr. Cobham: 436-4800 T. Carter: 436-4800 10.1.2
Colonade Mall	Mr. Steven Austin: 233-5513 Ms. Regret: 431-0936, 826-0699 10.1.3
NVN Plaza	Tyrone Hinckson (Tenant- property owner is oversees): 228-6724 10.1.4 Ms. Ramnarace (the owner that is overseas): 1-321-622-4628 , gaisons@yahoo.com 10.1.5 Ms. Ramnarace's son: 1-321-961-6044, ultimatesosundsfl@gmail.com
Berean Bible Church	Ms. Joyce Wells: 426-6201 Mr. Ronald Trotman: 237-8435, 426-4707, 420-1110 10.1.6
RBPF	Inspector Lewis: 430-7631, 256-2360 (contact person for the requested police surveillance) 10.1.7