NOISE LEVEL/ATTITUDINAL SURVEYS OF LONDON & WOODSTOCK, ONTARIO

J.E.K. FOREMAN, S.M. DICKINSON AND M.A. EMMERSON
Faculty of Engineering Science
The University of Western Ontario
London, Ontario, Canada, N6A 5B9

Physical and attitudinal surveys of community noise levels in the cities of London and Woodstock, Ontario, Canada were conducted. The noise monitoring, data retrieval, and data processing systems are described. A summary and discussion of the survey results are presented as a basis for the establishment of community noise regulations.

Introduction

The work described in this article was sponsored by the Ministry of the Environment of the Province of Ontario, Canada, together with the City of London, as part of an overall study to provide background information on existing noise levels and community subjective response to these levels. This information was required to assist the Ministry in formulating community noise regulations for the province as a whole, to assist municipalities in interpreting and implementing these provincial regulations on a local level and to provide guidelines for noise abatement and control procedures for future long-term urban planning. Other investigators concurrently conducted similar studies in Toronto[1] (sponsored by the City of Toronto) and Hamilton, and, subsequently, the Ministry conducted further studies in Sault Ste. Marie, North Bay and Kingston.

Approach Used

In addition to the overall sound level, there are a variety of physical characteristics which contribute to the unpleasantness of noise. Examples of these are its intermittency, its tonal content, the spectrum of dominant frequencies in the noise, its impulsiveness, the degree to which the noise intrudes into an otherwise quiet background. Many complicated rating scales have been devised in recent years to account for these factors.[2] These include PNdB (Perceived Noise Level), NNI (Noise and Number Index), SIL (Speech Interference Level), NC (Noise Criteria Number), NPL (Noise Pollution Level), CNR-community (Composite Noise Rating for Communities), TNI (Traffic Noise Index) and several others. Each of these indices has usually been designed for a specific purpose. While each has a basic utility, workers in the field of community noise measurements have become increasingly skeptical about the excessive complexity of some of the ratings and, indeed, the need for such precision. Many noted acousticians[3-9] have concluded that simple A-weighted sound levels, together with a simple statistical analysis (such as through probability distribution curves), give an acceptable assessment of the subjective sensation of loudness and are as meaningful a basis for establishing correlation between subjective response and physical noise measurements as are the more complicated ratings. On the other hand, such factors as intrusiveness of noise into an ambient situation (which describes the degree to which peak levels stand out above the ambient background) can be readily obtained by simple variations of the L_{10} and L_{90} measurements.[*,10,11] It was decided that for this survey the physical quantities sought should be the L_2, L_{10}, L_{50}, and L_{90} levels, TNI and NPL. An attempt would be made to establish what correlation, if any, existed between (1) a modified A-weighted sound level (such as L_{50}) and (2) a conventional rating scale (Noise Pollution Level NPL) and subjective responses in certain community land-use areas. The data acquisition and processing system was designed accordingly.

Research into the science of community noise surveys, through a review of the pertinent literature,[12,13] suggested that high accuracy in both the gathering of data and the assessment of this data could be obtained through the use of automatic, continuous duty, sound detection monitors rotated throughout well-defined grid patterns over pre-selected and representative zoning or land-use areas of the community, with which the block districts for the attitudinal interviews should coincide.

Based upon general knowledge of the two cities[†] and upon census lists - to ensure appropriate sample population representation of typical cross-sections of the two communities - six areas within London were selected and three within Woodstock. In London these corresponded to (a) residential (single family), (b) residential (single family, adjacent to quarry), (c) residential (multiple units), (d) residential-commercial, (e) residential-industrial and (f) residential-institutional, and within Woodstock to classifications (c), (d) and (e) preceding. Monitoring points approximately ¼ mile apart were selected and each was monitored on a 24-hour basis on at least a typical weekday, Saturday and Sunday, under "good weather" conditions (that is, when snow and ice conditions did not exist). In addition, "winter" (snow and ice conditions) monitoring was conducted at selected stations within the London areas. The numbers of monitoring stations involved and the tapes successfully recorded are summarized in Table 1.

Table 1 - Number of stations monitored in London and Woodstock and associated number of successful recordings obtained

	Number of Stations	Successful Tapes
London, Good Weather	57	165
London, Winter Conditions	18	46
Woodstock	18	54

Distribution of Monitoring Stations in London and Woodstock Land-Use Areas

London	
Residential-single family	6
Residential-single family (quarry)	6
Residential-institutional	9
Residential-commercial	12
Residential-industrial	12
Residential-multiple units	12
Woodstock	
Residential-multiple units	6
Residential-commercial	6
Residential-industrial	6

Concurrently with the physical noise monitoring, an opinion survey, utilizing an appropriate interview and questionnaire technique, was conducted in the selected block districts.

The data from these two surveys were processed with

*L_{10} is the level which is equalled or exceeded 10% of the time. Similarly, L_{90} is the level which is equalled or exceeded 90% of the time.

†Population of London is 235,000; Woodstock is 30,000.

the aid of digital computers and will be discussed in a subsequent section. The time period in which the project was undertaken was from May 1972 to September 1973.

The Automatic Monitor

A prototype monitor was designed and field tested and, subsequently, six field monitors were built. Each monitor consisted of a self-contained, light galvanized steel, weatherproofed box of approximately 13 x 10 x 10 inch dimensions, which included a high quality 2-channel stereo tape recorder, an external microphone and windscreen on a rotatable boom arm, a matching impedance transformer between the microphone and the tape recorder, a solid state electronic timer, and rechargeable battery power supply (see Figure 1). A 2-channel stereo tape recorder was chosen in order to obtain a dynamic range of 70 dB, which was accomplished by paralleling the microphone input to the recorder and attenuating and offsetting the input level to one of the tracks, overlapping the two channel levels by approximately 10 decibels. The measurement range chosen for this survey was from 35 to 105 decibels and the overall frequency response of the system was 40 - 16,000 Hz, the latter dependent upon the input signal level.

The timer was designed to switch the microphone and the tape recorder on and off at regular intervals totalling some 2 minute record time each hour. The prototype monitor was set to sample noises over 10-second periods every 5 minutes, in accordance with ref. 13, and would do this for 24 hours before requiring servicing (that is, recorder tape and battery change). However, at the request of one of the sponsors, the sampling interval and frequency of sampling of the field monitors was adjusted to 40-plus seconds of measurement every 20 minutes in order to conform to the method being followed in the survey of the City of Toronto.

An acoustic calibrator was used to provide calibration signals at the beginning and end of each 24-hour recording, both for a functional check and to aid in the computational processing of the recordings.

A van was equipped with the necessary instrumentation and calibration equipment for servicing the monitors, including a ladder for raising and lowering the monitors to and from their locations (usually 15 to 18 feet up a utilities pole).

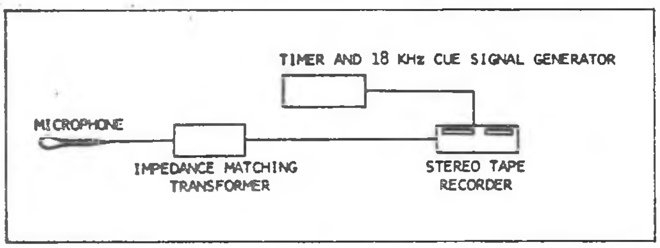

Figure 1 - Schematic diagram of noise monitor

Physical Measurements
Data Retrieval and Processing

The data retrieval and processing involved playback of the recorded tapes through a level detector gating circuit (which discriminated between the sound level on the upper or lower channel of the tapes), converting the information on the tapes to A-weighted rms sound levels, converting this information through a logarithmic potentiometer on a level recorder into decibel notation, and transferring the resulting information through an analog voltage read-out on the level recorder to cartridge tapes of a 7-channel FM tape recorder, as illustrated in Figure 2. The cartridge tapes were interfaced with the PDP 11 computer at the University Computing Centre for digitizing at half-second intervals.

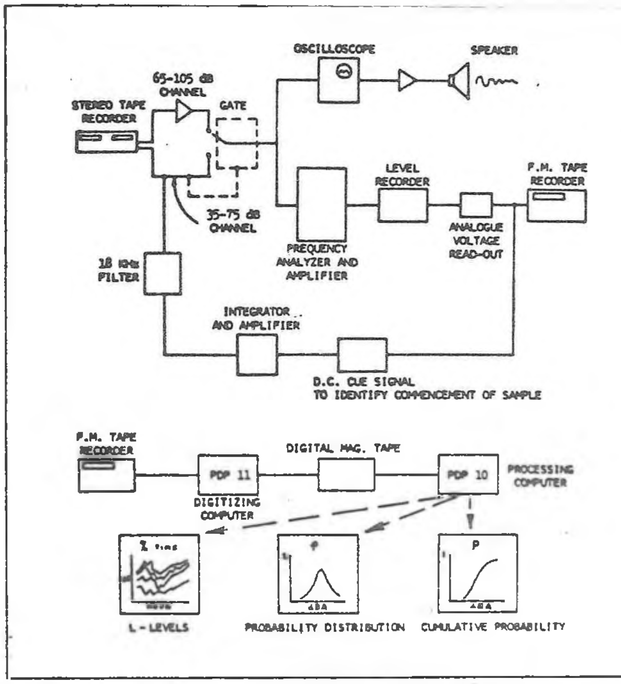

Figure 2 - Schematic diagram of data retrieval systems

All field tapes were audio-monitored during processing partly in order that a high level dc cue signal could be manually inserted on the FM tape at the commencement of each 40-second sample, the digitized value of which enabled the commencement of each sample of meaningful data to be identified during the computer processing. Upon the detection of each cue signal, the subsequent 40 seconds of information was sampled at half-second intervals, and transients due to recorder run up and run down were thereby eliminated. The audio-monitoring of the tapes also allowed the processor to detect and eliminate unwanted data (i.e. rain on the microphone and boom arm, excessive wind noise, etc.).

After digitizing, the data were processed using a PDP 10 computer and relevant information about the noise at each grid location was obtained directly in graphical form. This graphical output took the form of a plot of the L_2, L_{10}, L_{50} and L_{90} values by the hour over a 24-hour period (see Figure 3) and a plot of the percentage time particular noise levels were equalled or exceeded during the three time periods, 7:00 a.m. to 7:00 p.m., 7:00 p.m. to 11:00 p.m. and 11:00 p.m. to 7:00 a.m. (see Figure 4). The partially processed information generated to plot these graphs was stored on magnetic tape for possible further processing, should this prove desirable.

Results from Physical Measurements

Clearly, no attempt can be made in this article to present the vast quantity of data accumulated during the survey. Instead, mention will be made of the results to be found in the report to the Ministry[14] and only the summary of the results will be given here.

From the cumulative probability curves of the type shown in Figure 4, the value of L_{peak}, $L_{2.5}$, L_{10}, L_{50} and L_{90} were obtained and the corresponding indices TNI and NPL* determined for each of the three time periods. These L levels and indices were tabulated on the basis of monitoring location, day of the week and season. In order to arrive at a comparison in *mean* noise level between the various land-use areas in London and Woodstock, values of L_{50} and NPL were averaged and tabulated for each area for each of the three time periods for Saturday, Sunday and weekday (and by season for London). An example of these results,

*The values of NPL were calculated using the formula[9]

$$NPL = L_{50} + (L_{10} - L_{90}) + (L_{10} - L_{90})^2/60$$

Traffic Noise Index (TNI) = $4(L_{10} - L_{90}) + L_{90} - 30$.

which are believed to be representative of the noise levels occurring in medium sized and small sized cities within Ontario, is presented in Table 2 and gives averages of L_{50} and NPL for London land-use areas in good weather for various times of day and days of week.

Accuracy of the Sampling Procedure Used in Monitoring

In order to check the validity and accuracy of the sampling procedure chosen for the physical measurements (that is, recording 40-second samples every 20 minutes), 24-hour continuous recordings were made in two locations in London (one residential-commercial, the other residential) and were analyzed both on a continuous basis and on a sampled basis.

When sampling at the rate of 40 seconds every 20 minutes, the actual samples obtained depend upon the time of commencement of the initial sample and the exact time interval between each sample. It was therefore decided that three different sets of samples should be extracted from each continuous recording, each set commencing at a different time, the results from which should be compared with those obtained on a continuous basis.

A study of the plots obtained showed that the graphs based upon the hourly information (that is the "L_2, L_{10}, ..." graphs) were somewhat affected by the sampling procedure, particularly in the case of the L_2 and L_{10} values. This is to be expected since those statistics are based merely upon three samples (three samples/hour), together with the fact that, when sampling, short duration loud noises are easily missed but, if detected, their apparent duration is considerably amplified. In the case of the cumulative probability graphs, which are based upon longer time periods, and hence upon greater numbers of samples, close agreement was found to exist between the "sampled" and the "continuous" results, especially in the case of the time period 7:00 a.m. to 7:00 p.m.; this period corresponded to one of the assessed periods in the attitudinal survey and respective correlation study.

Table 2 - Averages of L_{50} and NPL for various land-use areas, times of day, days of week and seasons in dBA

London - Good Weather

Period	Saturday L_{50}	Saturday NPL	Sunday L_{50}	Sunday NPL	Weekday L_{50}	Weekday NPL
Residential (Quarry)						
7:00 - 19:00	55.0	69.0	52.5	69.0	56.1	73.0
19:00 - 23:00	52.2	67.7	48.5	67.0	51.3	66.6
23:00 - 7:00	47.5	63.5	45.8	65.2	45.3	66.1
Residential - Single						
7:00 - 19:00	53.1	69.4	54.5	71.3	53.0	71.0
19:00 - 23:00	49.1	62.3	52.5	69.7	49.7	67.0
23:00 - 7:00	45.4	56.7	46.5	59.3	45.0	61.9
Residential - Institutional						
7:00 - 19:00	53.7	72.2	53.7	74.9	56.7	75.5
19:00 - 23:00	51.5	69.7	51.3	69.6	52.9	72.1
23:00 - 7:00	48.1	57.8	47.2	59.9	45.5	58.7
Residential - Commercial						
7:00 - 19:00	60.1	76.4	58.5	77.3	63.2	77.7
19:00 - 23:00	55.7	71.6	57.3	75.0	59.1	72.1
23:00 - 7:00	50.7	69.8	51.0	70.2	53.2	75.1
Residential - Mixed						
7:00 - 19:00	57.3	74.0	54.0	73.6	56.9	73.7
19:00 - 23:00	54.0	71.6	51.7	71.0	52.8	68.7
23:00 - 7:00	49.7	63.4	45.4	64.4	49.1	64.5
Residential - Industrial						
7:00 - 19:00	56.4	72.6	54.1	71.6	57.5	73.6
19:00 - 23:00	54.5	69.3	53.0	68.3	53.6	68.8
23:00 - 7:00	50.5	67.5	47.7	63.5	50.8	67.7

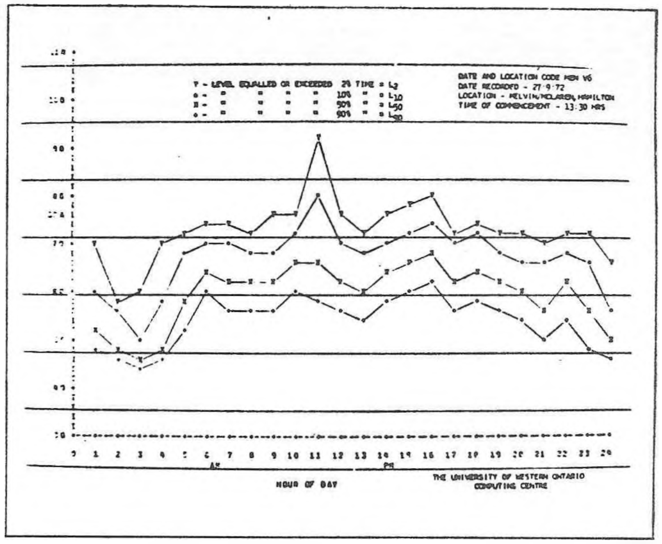

Figure 3 - Typical plot of levels exceeded 2, 10, 50 and 90 percent of the time, by the hour

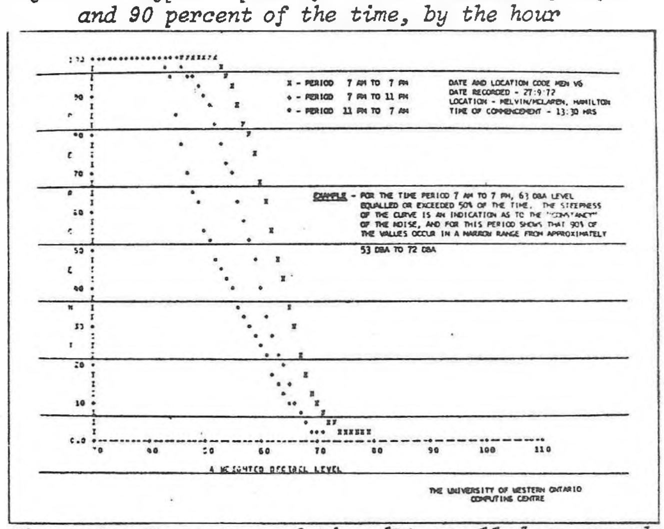

Figure 4 - Percentage of time dBA equalled or exceeded during three time periods

A comparison between the L_{peak}, $L_{2.5}$, L_{10}, L_{50} and L_{90} values extracted from these latter graphs and the appropriate TNI and NPL values showed that the variation between the "sample" and the "continuous" values for L_{10}, L_{50} and L_{90} was greater than 2 dBA in only one instance and was frequently less than 2 dBA.

Table 3 - Maximum difference in dBA between the "continuous" and "sample" L_{50}, TNI and NPL values for the three time periods

Location	Time Period	ΔL_{50}	ΔTNI	ΔNPL
Residential-Commercial	7:00 - 19:00	1	4	2
	19:00 - 23:00	2	7	3
	23:00 - 7:00	2	8	4
Residential (Single Family)	7:00 - 19:00	1	4	2
	19:00 - 23:00	1	1	1
	23:00 - 7:00	1	12	6

Table 3 shows the maximum variation between the L_{50}, TNI and NPL values for the "sample" and "continuous" analyses for the three time periods for the two locations. For both locations, it may be seen that the TNI value is more affected by the sampling procedure than either the L_{50} or NPL. This is again to be expected, since it has a heavy dependence upon the L_{10} - L_{90} value (it being weighted by a factor of 4) which is likely to be affected by the sampling procedure. For similar reasons, though to a lesser extent, the NPL value is more affected by the sampling procedure than the L_{50}.

In summary, it would appear that the sampling procedure used is likely to provide considerable under or over estimation of peak or near peak values, especially on an hourly basis, but, over the longer time periods of 7:00 a.m. to 7:00 p.m. etc., the L_{10}, L_{50} and L_{90} values are reasonably representative of the true values. The value $L_{10} - L_{90}$, however, may tend to err rather more due to the possibility of compounding errors; thus the TNI values, which involve this value weighted four times, may be somewhat in error.

Results From Attitudinal Survey

The object of the study of the attitudes of the residents of London and Woodstock to the noise in their neighbourhood was to see whether these people reacted to noises in accordance with the degree of noise measured by the objective measuring instruments in the neighbourhood or whether the attitudes of people were independent of the objective noise level measures.

In addition, it was of interest to know which noises were most bothersome in the neighbourhoods, at what times during the day and year, what citizens had done about bothersome noises and what they were prepared to do about them.

Sample. The object of the sampling design was to find a probability sample of people to interview within a reasonable range of the point at which noise levels were being monitored. A multi-stage probability sampling of blocks was carried out in the six areas in which noise measurements were being taken. Within each of the blocks drawn in the sample, interviewers located respondents on a pre-designed format which was congruent with the maintenance of probability sampling. In total, eight hundred householders were interviewed.

An analysis of the data collected indicated that the sample population was widely representative of the people living in the areas in terms of age, income and education.

Questionnaire: Design, Reliability and Validity. Questions were designed in order to achieve the maximum amount of information in as short a time as possible, that is, to get the full range of people's responses to noise in their neighbourhood while not taxing their patience with the interviewers. An analysis of the questions and the responses indicated that there was a high degree of reliability in response.

Each of the questionnaires was pre-tested and refined over a period of some months. The interviewers were trained in the goals and methods of sampling and asking questions and were carefully supervised throughout the project.

Highlights of Social Survey. The following summarize the major general findings of the social survey.* Specific reference to a correlation between attitudinal responses and physical measurements will be dealt with in a later section.

Perceptions of Noise Levels

Responses to a question asking respondents to estimate the degree to which they were bothered by noise in their neighbourhood showed that 36% were not bothered by noise at all, or reciprocally, 64% of respondents were bothered by noise to some extent. Only 3% of the people interviewed said they were extremely bothered by noise and, on a scale of one to seven where one was "not bothered at all" and seven "extremely bothered", 73% of the respondents were bothered to a degree of only 4 or less. Thus one can report that less than a quarter of citizens were really bothered by the noise in their neighbourhood.

A whole series of questions were then asked about noise and its effects and, at the end of the interview, the questionnaire returned to the first questions and asked the respondents to estimate the degree to which noise bothers them on a scale of 1 (low) to 7 (high). This was to test the extent to which the process of being interviewed had caused them to change their perceptions of noise in their neighbourhood. The change in response was marginal. In fact, if anything, people responded to the end of the scale which indicated not being bothered by noise, but the differences were not statistically significant.

Most Bothersome Noise Sources

While there were some people who were bothered by a wide range of noises, on the whole the chief sources of disturbance were domestic (radio, television, record players, pets and garden machinery) and, outside the domestic setting, passing cars, motor cycles, diesel trucks and squealing tires.

The following percentages refer to that proportion of respondents who were bothered to any extent by the noise source mentioned. The reciprocal of the number is the percentage who were not bothered by that noise source at all.

motorcycles	55%	children	31%
passing cars	50%	record players	25%
transport trucks	43%	radio	25%
squealing tires	42%	television	23%
revving engines	42%	passing trains	20%
domestic pets	36%		

Action Taken

When respondents were asked what action they had taken to control these noises in their lives, it was found that 85% had taken no action whatsoever. Of the remaining 15% some had called the police, some had told the person causing the noise that it was disturbing them and a few had moved to a quieter neighbourhood - or planned to.

Effects of Noise Upon Health

Respondents were asked if they felt that the noise in the neighbourhood was harmful to their health. Seventy percent felt that it was not at all harmful. Of the other 30% only 1% felt that the noise was very harmful to their health with a range of other responses indicating that the others felt it to be only somewhat harmful to their health.

Alternatively, the question was asked to what extent loud noises over a length of time contributed to a number of disorders including hearing loss, irritability, headaches, nervousness and insomnia; quite a number of citizens felt that it did indeed contribute to these conditions. The percentage of respondents who felt that noise contributed at all to these conditions is given below:

hearing loss	75%	headaches	65%
nervousness	76%	insomnia	65%
irritability	81%		

Perceptions of Legal Protection

There are municipal by-laws regarding noise in the cities studied (though they are interpretive and somewhat unenforceable). Thirty-four percent of respondents thought there were by-laws while 22% thought there were not. Another 44% did not know. When asked the degree to which they felt the laws protected them against disturbance by noise, the majority of respondents straddled the fence and said the laws protected them neither well nor badly.

Noise Pollution Compared to Air Pollution

Very little difference was perceived by these residents of London and Woodstock between the problem of noise and air pollutions in their neighbourhoods.

*Prepared by E.B. Harvey, Ontario Institute for Studies in Education, and L.R. Marsden, Population Research Group, University of Toronto

Thirty-six percent felt that air pollution was not a problem at all and 40% felt that noise pollution was no problem at all; 21% felt that air pollution was a little bit of a problem and 22% felt that noise was a little bit of a problem. At the other end of the scale, 3% felt air pollution to be an extreme problem and 2% felt that noise was an extreme problem. Neither form of pollution was felt to be a major problem in the neighbourhoods studied.

Noise Disturbance and Time of Day

Noise was seen as more of a problem during the day and evening by most people and not much of a problem from midnight to early morning. Only 5% of the respondents worked 24-hour shifts.

With respect to the comparison between weekends and weekdays, there was little difference. Fifty-four percent of respondents found noise something of a nuisance on weekends and 55% found it somewhat bothersome on weekdays. Only 8% more respondents said noise was extremely more bothersome on the weekends.

Seasonally, summer was found to be the noisiest season, followed by fall and spring and then winter.

Paying for Noise Abatement

Asked if they were willing to pay for noise abatement procedures in their neighbourhood, 79% of the citizens were not willing to pay anything at all; 21% were willing to pay between \$1 and \$100.

Correlation between Physical Measurements and Subjective Responses. As mentioned at the outset of this article, it was intended to examine the degree of correlation between (1) a modified A-weighted sound level (such as L_{50}) and (2) a conventional rating scale (Noise Pollution Level NPL) and subjective responses in community land-use areas. To date, this examination has been restricted to the results for the good weather survey of the City of London, but it is intended that the analysis should be extended subsequently to Woodstock, and London and Woodstock combined.

The results of the above correlation study are summarized in Table 4 which presents correlation coefficients for selected NPL values and L_{50} values with the percentage of respondents scoring "noise bother" $\geq$ 2 or $\geq$ 5 on a 7-point scale. It may be interpreted that the percentage of respondents scoring noise bother $\geq$ 2 is the percentage which is *at all* bothered by noise, whereas the percentage scoring $\geq$ 5 is that percentage which is *highly* bothered by noise. The results shown in column 1 of Table 4 suggest that there is good correlation between the L_{50} and NPL values, determined over 24 hours and averaged for Saturday, Sunday and a weekday, and the percentage of respondents *at all* bothered by noise; there is also a good correlation between the daytime L_{50} values, either weekday or averaged for Saturday, Sunday and a weekday, and the respondents *at all* bothered. The results of column 2 indicate that there is less correlation between the percentage respondents *highly* bothered by noise and all L_{50} or NPL values. However, examination of the correlation between the percentage of respondents *highly* bothered by the *ten most significant* noises with the NPL and L_{50} values, as given in column 3, shows that good correlation exists for the daytime NPL values, while there is little correlation in the case of the remainder.

Figures 5, 6 and 7 graphically illustrate the relationship between the subjective response and the various NPL and L_{50} values for the six cases in which the higher correlations were observed.

The results presented tend to suggest that, for the City of London, both the NPL and L_{50} values give acceptable assessments of the subjective sensation of noise, the former seemingly partially related to *high* degrees of annoyance and the latter to *any* degree of

Table 4 - Correlation coefficients associated with the percentage of respondents bothered by noise and average NPL and L_{50} values for the City of London

Index	Percentage of Respondents Scoring Noise Bother $\geq$ 2 All Noises	$\geq$ 5 All Noises	$\geq$ 5 Ten Most Significant Noises*
NPL, 7:00 to 19:00, Average of Saturday, Sunday and Weekday	0.76†	0.60	0.86
NPL, 7:00 to 19:00 Weekday Only	0.73	0.58	0.82
NPL, 24 hour, Average of Saturday, Sunday and Weekday	0.88	0.73	0.65
L_{50}, 7:00 to 19:00, Average of Saturday, Sunday and Weekday	0.85	0.69	0.57
L_{50}, 7:00 to 19:00 Weekday Only	0.86	0.71	0.64
L_{50}, 24 hour, Average of Saturday, Sunday and Weekday	0.91	0.78	0.55

**The ten most significant noises are those for which the highest correlation was obtained between the response of the interviewees of each land-use area to individual noise sources and their overall response to noise.*

†These values were computed on the basis of six data points in each case, corresponding to averaged response and levels in the six land-use areas. Thus, using a two-tailed test of Student's distribution, the minimum values of the correlation coefficients for probability levels of 1%, 5%, 10% and 20% are found to be 0.92, 0.81, 0.73 and 0.61 respectively.

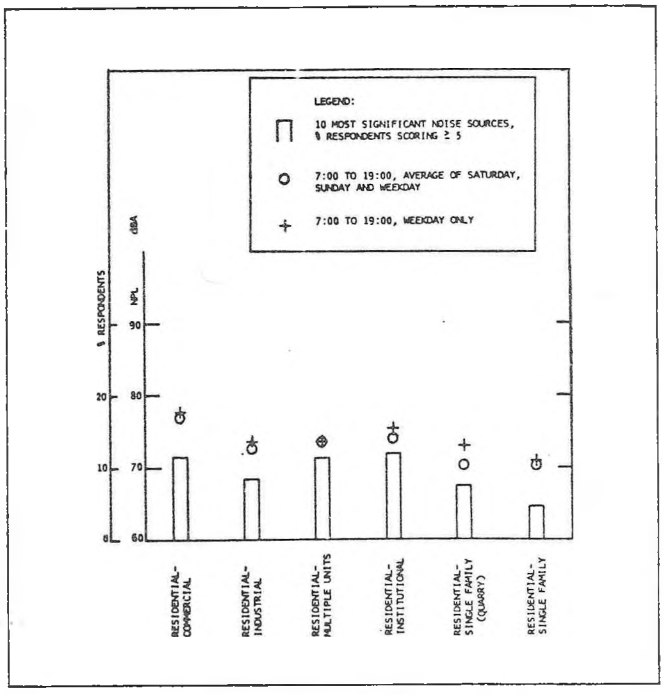

Figure 5 - Noise Pollution Level (NPL) and percentage of respondents scoring "noise bother" $\geq$ 5 on a 7-point scale for London land-use areas, good weather

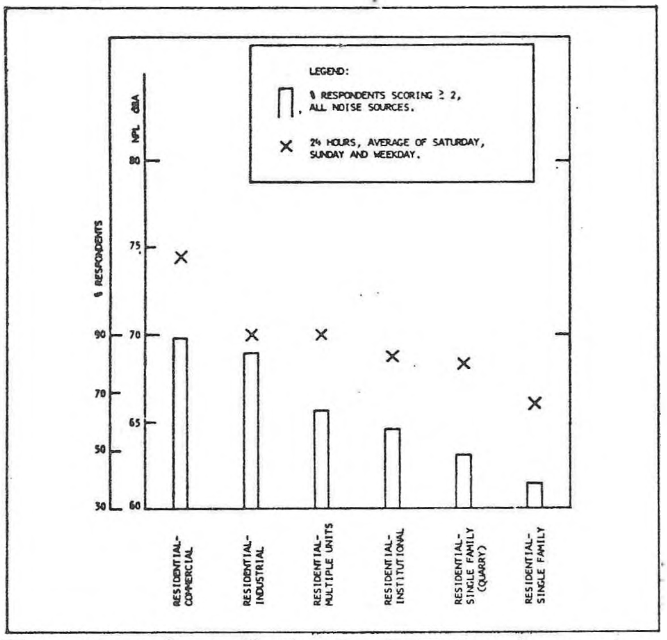

Figure 6 - Noise Pollution Level (NPL) and percentage of respondents scoring "noise bother" ≥ 2 on a 7-point scale for London land-use areas, good weather

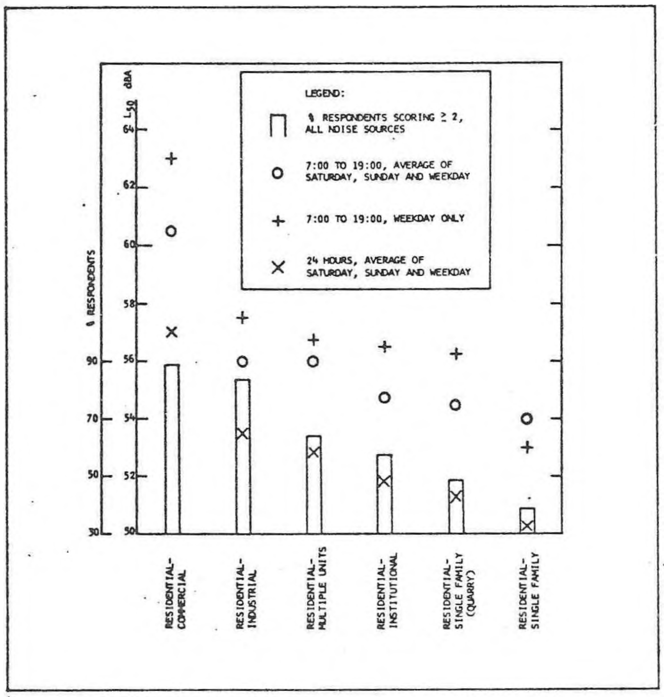

Figure 7 - Noise Level L_{50} and percentage of respondents scoring "noise bother" ≥ 2 on a 7-point scale for London land-use, good weather

annoyance.

It should be recognized that the correlation results presented are each based upon only six data points, although each of the six points was derived from the considerable amount of physical measurement and attitudinal survey data gathered from one of the six land-use areas of the city. It should also be observed that the correlation study conducted to date is of a preliminary nature and that it is intended that further studies should be conducted in this area.

References

1. Koczkur, Broger, Henderson and Lightstone, "Noise Monitoring and Sociological Survey in the City of Toronto", presented at the 65th Annual Meeting of the Air Pollution Control Association, Miami Beach, Florida, June 18-27, 1972.
2. T.J. Schultz, *Community Noise Ratings*, Applied Science Publishers Ltd., London, 1972.
3. J.H. Botsford, "Using Sound Levels to Gauge Human Responses to Noise", *Sound and Vibration*, 3 (10) (1969), pp.16-28.
4. R.W. Young and A. Peterson, "On Estimating Noisiness of Aircraft Sounds", *J. Acoust. Soc. Am.*, 45 (1969), pp.834-8.
5. R.W. Young, "Single-Number Criteria for Room Noise", *J. Acoust. Soc. Am.*, 36 (1964), pp.289-95.
6. W. Connor, "A Predictive Equation for Estimating the Level of Annoyance of the Airport Community", presented to the Committee on Hearing and Bio-Acoustics, Washington, D.C., 20 November 1969.
7. Literature Survey for the FHA Contract On Urban Noise, Report No.1460, January 1967, Bolt, Beranek and Newman, Inc.
8. Noise in Urban and Suburban Areas: Results of Field Studies, Technical Study FT/TS-26, March 1968, by Bolt, Beranek and Newman, Inc., Los Angeles, for Federal Housing Administration, Dept. of Housing and Urban Development.
9. D.W. Robinson, "Towards a Unified System of Noise Assessment", *J. Sound Vib.*, 14 (3) (1971), pp.279-298.
10. F.J. Langdon and W.E. Scholes, "The Traffic Noise Index: a Method of Controlling Noise Nuisance", Building Research Station CP38/68, *Arch. Journ.*, 147 (17 April 1968).
11. D.W. Robinson, "An Outline Guide to Criteria for the Limitation of Urban Noise", NPL Aero Report Ac39, National Physical Laboratory, Aerodynamics Division, March 1969.
12. R. Josse, "Comment Mesurer et Caractériser les Bruits", presented at a Colloquium on the Definition of Human Requirements with Regard to Noise, 18 and 19 November 1968, Paris; *Revue d'Acoustique*, 3 (10) (1970), pp.131-9.
13. T.J. Schultz, "Some Sources of Error in Community Noise Measurement", *Sound and Vibration*, 6 (2) (1972), pp.18-27.
14. J.E.K. Foreman and S.M. Dickinson, "Noise Measurements and Attitudinal Surveys of the Cities of London and Woodstock, Ontario, Canada", Report #1 to the Department of the Environment of the Province of Ontario, September 15, 1973.

Acknowledgement

This article appeared in the December 1974 issue of Sound and Vibration, and is reproduced here with the permission of the publisher.