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DATA ON NOISE ENVIRONMENTS AT DIFFERENT
TIMES OF DAY AROUND AIRPORTS

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SUMMARY

Sources of information about noise environments at different times of day are examined for both civilian and military airports in the United States. The Official Airline Guide (OAG) contains machine readable information about the timing of scheduled flights for each airport as a whole. An analysis of the OAG data finds that the percentages of nighttime flights at large airports (greater than 100 scheduled flights a day) vary from 3% to 18%. If flights were uniformly distributed between different flight paths at these airports the differences between daytime and nighttime noise levels (measured in Equivalent Continuous Noise Level, LEQ, dB(A)) would vary from 7 to 15 decibels. The OAG data do not provide information about the timing of flights for particular ground tracks.

Noise measurement data from permanent noise monitoring sites can provide information about daytime and nighttime aircraft noise levels at particular locations around airports. In this report 6009 days of data from 128 permanent noise monitoring sites at 11 airports are examined. Differences between daytime and nighttime noise levels at these 128 noise monitoring sites vary from 3 to 17 dB(A) LEQ.

The OAG and noise monitoring data are compared for 9 airports. While the data are not usually inconsistent, it is found that the correlation between the measures of day-night differences derived from the two data sets is no more than r=0.60. The noise monitoring data show that day-night noise level differences can vary considerably between different sites at the same airport.

Some information about movements of aircraft at military installations has been collected as part of Air Installations Compatible Use Zones (AICUZ) programs. Some data are available at central locations for both Navy and Air Force flight facilitites. Limited information about the timing of flights is readily available for Naval facilitites, but more detailed information about the distribution of flights for particular flight paths is not available centrally. The Air Force has detailed data about the timing of aircraft movements stored on computer tapes in a central location, but the data are not aggregated to provide information about noise environments at different times of day.

Preliminary analyses suggest that accurate estimates of the time-of-day weights used in environmental noise indices could not be obtained from conventional social surveys at existing commercial airports.

INTRODUCTION

The estimation of the relative impact of noise at different times of day has been a goal of much community noise research (Fields, 1985). The single most serious obstacle to obtaining these estimates from existing surveys has been the high correlation between daytime and nighttime noise levels. These high correlations in existing social surveys have meant that no single survey has, by itself, provided a satisfactorily precise estimate of the time-of-day weighting factor. The chief requirement for a future study is thus that suitable noise environments be located.

This report examines three sources of information about noise environments at different times of day. Information about all civilian airports in the United States has been obtained from the computerized Official Airline Guide (OAG) files. Information about airports with permanent noise monitoring systems has been obtained by analyzing 6009 days of noise monitoring information from 128 permanent noise monitoring sites at 11 airports. Information about noise environments at military airports has been obtained from contacts with the appropriate personnel in each branch of the armed services.

Some information is given about the availability and likely precision of the noise data. In general, however, the main purpose of this report is not to provide a detailed, comparative analysis of all aspects of the data sets, but rather to obtain only as much data as are needed to assess the likelyhood that noise environments could be found which would enable a study to provide estimates of the time-of-day weighting factor.

The data in this report could provide the basis for an analysis of several alternative time-of-day study designs. The present report, however, considers only the conventional cross-sectional survey design.

SYMBOLS AND ABBREVIATIONS

a,c,q	Constants used in noise indices
B	Partial regression coefficient for time period (j) or noise index (I)
CNEL	Community Noise Equivalent Level, dB
CNR	Composite Noise Rating
D_{L_j}	Decibel value to be added to the single event sound level or single hour LEQ for time period j before being summed, (decibel weight), dB
LDN	Day-night Average Sound Level
LEQ	Equivalent Continuous Sound Level for period j, dB(A) (All values for LEQ are A-weighted.)
L_I	Noise level for noise index I, dB

L_{ij}	Sound level of noise event i in period j. This is normalized to a 24-hour period. Thus it is the 24-hour LEQ value for event i in period j. The relative sound pressure squared is thus $10^{L_{ij}/10}$).
N	Number of noise events
NEF	Noise Exposure Forecast
OAG	Official Airline Guide
t_j	Number of hours in period j
w_j	Weight to be multiplied by number of events (N) or relative sound pressure squared ($10^{(L_{ij}/10)}$) for period j
WECPNL	Weighted Equivalent Continuous Perceived Noise Level, dB
σ	Standard deviation

Additional Subscripts

d	Daytime period
i	A single noise event
I	Noise index I
j	A time period
k	A person
L	Noise level
n	Nighttime period

Definition of Adjusted Energy Noise Index with Nighttime Weight

Adjusted energy noise indices which include a nighttime weighting include LDN, CNEL, NEF and CNR. These indices can be written in a general form in which a multiplicative weight (w_n) is applied to the number of noise events or the relative sound pressure squared. The general form for these indices is:

$$L_I = a + c \bullet 10 \bullet \log_{10} \left[\left(\sum_{i=1}^{N_d} 10^{L_{id}/10} + w_n \bullet \sum_{i=1}^{N_n} 10^{L_{in}/10} \right) / 24 \right]$$

The indices also can be written with the additive decibel weight (D_{L_n}) rather than the multiplicative weight.

$$L_I = a + c \bullet 10 \bullet \log_{10} \left[\left(\sum_{i=1}^{N_d} 10^{L_{id}/10} + \sum_{i=1}^{N_n} 10^{(L_{in}+D_{L_n})/10} \right) / 24 \right]$$

The decibel weight (D_{L_n}) is a simple logarithmic transformation of the multiplicative weight:

$$D_{L_j} = 10 \bullet \log_{10}(w_j)$$

In CNR and NEF the multiplicative weight is w_n=16.7 and the additive decibel weight is D_{L_n}=12.2.

CIVILIAN AIRPORT INFORMATION FROM OAG FILES

Data

The Official Airline Guide (OAG) data base includes all regularly scheduled air carrier flights. While the details of exactly what types of flights might be included or excluded would be important in assessing the environment at a particular airport, it would appear that the OAG data is probably satisfactory for the present purposes. There may be some underestimation of nighttime flights because not all air freight movements are included. Unscheduled flights of General Aviation aircraft are excluded as are movements by military aircraft at these civilian airfields. While any of these exclusions could be important in evaluating the noise environment at small airports, they are probably insignificant for the relatively large airports (at least 100 movements a day) which are considered here.

The data analyzed in the following section come from a single weekday (Wednesday, October 19, 1983). The data which have been examined are numbers of arrivals and departures of each aircraft type at three times of day. However, for this report all data have been aggregated to provide airport totals from the two standard time periods defined in LDN: daytime (0700 to 2159) and nighttime (2200 to 0659).

Results

If a study were to be based on comparisons of reactions at different airports then the critical question is whether there is sufficient variation between airports in the proportions of flights at different times of day. This variation has been explored by identifying the airports with the most extreme proportions of daytime and nighttime flights. The results of this investigation are presented in table 1. (Only airports with at least 100 movements a day have been examined.)

Table 1 presents information on 26 airports: the 5 airports with at least 15% of the flights at night and the 21 airports with no more than 5% of the flights at night. The range in percentage of flights at night extends from 18% at Memphis to 1%

at Burbank. If it is assumed that the effect of number of events is correctly represented by an equivalent energy model, then the information on number of events can be used to create estimates of the differences in decibels (LEQ) which separate daytime and nighttime noise levels. In the absence of information to the contrary, it is assumed that the peak noise levels and durations per flight are the same for the daytime and nighttime periods. The estimated decibel differences between the daytime and nighttime values of LEQ are given in the last column. The differences range from a low of 6 decibels to a high of 19 decibels.

Implications for Study Design

The critical question with respect to study design is whether or not the reported differences between airports could be sufficient to provide a basis for an accurate estimate of the relative importance of noise at different times of day. A detailed examination of this question is beyond the scope of this report. At this point the objective is only to perform an initial screening to determine whether a study would be feasible under relatively optimistic assumptions. For this purpose an estimate has been made of the 95% confidence interval which could be obtained from a study based on airports identified in the OAG file.

To make this estimate it is necessary to make a large number of assumptions. These assumptions and the statistical procedures are described in more detail in appendix A. It is assumed that a study can be designed with three airports which have day-night noise level differences of 7, 10 and 15 dB(A) (LEQ). Confidence intervals have been calculated for different size samples for the case in which the study provides an estimate of the nighttime weighting of 10 (the weighting used in LDN). Under rather optimistic assumptions a sample size of 1000 would be sufficient to establish that the nighttime weighting of ten was significantly greater than zero. However, a sample size of roughly 5,000 to 10,000 would be required to establish that the nighttime weighting was significantly greater than 5. These sample sizes would not be able to establish upper limits for the estimate. Even for a sample size of 30,000, it is optimistic to assume that a 95% confidence interval for the weighting would extent from only $w_n=7$ to $w_n=17$ ($D_{L_n}=8.5$ dB to $D_{L_n}= 12.2$ dB). In short it might be feasible to establish whether a nighttime weighting was needed, but it would most likely be prohibitively expensive to specify the size of the weighting with any degree of precision. The final conclusion on this issue must however be postponed until some of the assumptions implicit in these estimates can be examined more rigorously.

INFORMATION FROM PERMANENT NOISE MONITORING SYSTEMS

Data

A search of information available at the FAA Washington headquarters produced a list of 35 airports which might have permanent noise monitoring systems. Of these 35 airports, it was determined that 24 airports were not candidates for a time-of-day study. The reasons for excluding these airports are listed in table II. In most cases either the airport was very small, only mobile noise monitoring was performed, or information was collected about only the small number of operations which violate noise regulations. All of the 11 remaining airports (listed in table III) did provide data for this repoort.

Each of the eleven airports provided the NASA Langley Research Center with 5 to 190 days of hourly noise levels (LEQ, dB(A)) for each of the permanent noise monitoring sites. The eleven airports have a total of 128 permanent noise monitoring sites. A total of 6009 days of noise monitoring data were entered into a computer file and processed using analysis programs in the Statistical Package for the Social Sciences (SPSS) (Nie et al., 1975). The most detailed available data are these hourly values of LEQ. Data on the numbers and noise levels of individual events are not routinely recorded.

The data reported here were readily available and relatively economically processed. Only a few general observations can be made about the precision of the noise estimates. Whether or not the noise data are precise enough to use in a time-of-day study could only be determined if there were on-site observations or noise measurements. The simple visual examination and limited computer-based data editing applied to these data found some problems with the noise monitoring data. In several instances noise levels from adjacent noise monitoring sites were obviously not congruent. More often the daily summary report for a day would show that there were valid data for less than 24 hours, but the report would not indicate which of the "zero" noise level hours had no valid data and which of the hours had correctly reported no measured aircraft noise events. In the present analyses these problems were resolved by deleting the questionable hours from the calculations of averages.

If a field study were to be conducted based on the noise monitoring system it would be necessary to closely examine the monitoring system operation at each site. For long-term studies the routinely collected data could probably be used to compute long-term average noise levels if auxiliary noise measurements were made at each of the individual sites for a small number of days. If reactions to short-time noise exposures were studied, it would almost certainly be necessary to have personnel at the centralized data collection point and perhaps some other points to check the data acquisition process during the study period. A major issue that would need to be examined is the accuracy of the data when there are low noise levels. With hourly LEQ values of less than 45 dB, the threshold set for the noise monitoring system could be of considerable importance. Especially at night with windows open, there would be audible aircraft noise events which would not be routinely accumulated by these permanent noise monitoring systems.

Results

Twenty-four energy averaged hourly noise levels were calculated for each of the 128 permanent noise monitoring sites. Energy averages of the appropriate hours then provided measures of LEQ for a 9-hour nighttime period (2200 to 0659), a 3-hour evening period (1900 to 2159), a 12-hour daytime period (0700 to 1859) and a 15-hour daytime period (0700 to 2159). Detailed data on the noise levels during these periods at each of the 128 sites are provided in appendix B. Appendix C contains maps which are keyed to the appendix B tables. The maps show noise levels at all sites. The noise level data have been summarized in table III in the text in terms of the differences between daytime and nighttime noise levels and the variations in these day-night differences between the different sites at each airport and between the different airports.

The average of the differences between nighttime and daytime aircraft noise levels at the 128 sites is 10.1 dB(A) (LEQ) (last line of the second column of data in table III). The means for the 11 airports cluster rather tightly around this value: the airport averages range from 5.7 dB at Los Angeles to 14.4 dB at John Wayne. The standard deviations of the differences (next-to-last column) are rather small: σ=4.2 dB for the sample as a whole. Only two airports have standard deviations which are greater than σ=4 dB (John Wayne and Ontario). The correlations between daytime and nighttime noise levels are quite high (last column of table III). The overall correlation is r=0.91. Seven of the 11 airports have correlations greater than r=0.85. Two of the four airports with lower correlations have such small standard deviations in the daytime noise levels that they would not by themselves provide suitable study sites (Van Nuys with a standard deviation of σ=1.8 dB in the third data column and Burbank with a standard deviation of σ=2.9 dB). The suitability of other sites for a study is discussed in a later section of this report.

The differences between daytime and nighttime noise levels tend to increase with increasing noise level. The correlation between the daytime value of LEQ (15 hr.) and the day-night difference is r=0.30. This shows that the sites with the greatest number of flights or the highest peak levels are likely to have the greatest day-night difference.

Comparison of OAG and Noise Monitoring Data.- Both the OAG and noise monitoring data are available for nine airports. This makes it possible to explore the feasibility of using the OAG data as a basis for selecting airports for a time-of-day study. The estimates of the differences in daytime and nighttime noise levels from the two sources of data are compared in table IV. The day-night differences (in decibels) expected from the numbers of scheduled flights in the OAG are given in the second data column of table IV. The day-night differences at the noise monitoring sites around the airports are presented both in terms of the range of differences around each airport (next-to-last column) and the mean of the site differences at each airport (previous column). The OAG information and the noise monitoring data provide rather similar estimates. In all but three cases the OAG estimate is included in the range of values found at the noise monitoring sites. Except for the large discrepancy at Burbank, all of the OAG estimates are within four decibels of the mean of the noise monitoring site values (last column of table IV).

The three of four decibel discrepancies must however be considered in relation to the standard deviation of the statistic. In table II it was seen that the standard deviation of the daytime minus nighttime difference is only $\sigma=4.2$ dB. As a result the correlation between the OAG estimate and the airport means for the noise monitoring sites is only $r=0.37$ for all sites. The correlation rises to $r=0.58$ if Burbank is excluded. There is a weak tendency in the data set for the OAG data to give a higher estimate for the nighttime noise levels. The OAG data thus provide only moderately good estimates of the differences in measured daytime vs. nighttime noise levels.

One of the statistics which has the greatest influence on the success of a sample design is the variation in the day-night differences. The important question is whether the OAG data, which assume that all sites within an airport have the same day-night difference, would provide an adequate estimate of the variation in the day-night differences if several airports were used. For eight airports in table IV (the extreme Burbank value is excluded), the OAG data predict a standard deviation for day-night differences of $\sigma=2.0$ dB. The data from the 102 noise monitoring sites around these airports have a standard deviation of the day-night differences of $\sigma=4.2$ dB. Thus, in this instance, the OAG data underestimate the variability of the data and also provide a conservative estimate of the quality of a sample design.

It is not immediately clear why the OAG and noise monitoring data should provide different estimates. The data from the two sources generally come from the same year (years for noise monitoring data are given in the table; OAG data come from October 1983). It seems unlikely that, with the possible exception of Washington National, any differences in results should be traced to changes in operating conditions in the different years. There may of course be genuine variation in the relative proportion of day and night traffic at the different locations around any one airport. It also may be that there are systematic biases in the noise monitoring data, possibly because of the noise thresholds built into the systems.

Implications for Study Design

If the noise monitoring data are accepted as accurate, the question again arises as to whether the noise monitoring data could provide a basis for study which would provide a satisfactorily precise estimate of the nighttime penalty. Just as for the previous analysis of the OAG data, various assumptions are made (described in appendix A). In the case of the noise monitoring data, however, the data are available for the 128 individual sites. As a result no untested assumptions need be made about the uniformity of the differences between noise levels around each airport.

The results of this analysis are very similar to those from the examination of the OAG information. A sample size of 1000 might be sufficient to establish that a nighttime weighting is needed; however, even if it were possible to obtain 10,000 interviews from the ten airports and there were no other important differences between airports, the 95% confidence interval for the 10-unit night penality would range from $w_n=6$ to $w_n=24$ ($D_{L_n}=8$ dB to $D_{L_n}=14$ dB). More detailed analyses would be required to determine exactly what characteristics of the distribution of the noise levels at monitoring sites lead to such inaccurate estimates. Such a broad confidence interval would probably be unacceptable for most purposes. It thus appears that the noise monitoring sites as presently located do not provide a satisfactory basis for designing a social survey to estimate the time-of-day penality.

MILITARY AIRPORT INFORMATION

Contacts with the Army have indicated that most US Army operations are helicopter operations and thus there are no Army-operated airports with sizeable numbers of operations of large fixed wing aircraft. Both the Navy and Air Force do however have a number of airports with substantial numbers of operations. In both cases some standardized information is available in an easily accessible central location.

The operations at these military installations differ considerably from one another. There are, however, several respects in which the timing of operations at military airports generally differs from that at civilian airports.

Most military installations have only very limited, regular weekend activities. The only installations with extensive weekend activities might be ones with extensive Air National Guard activity. The extent to which activities are concentrated during the daylight hours probably varies considerably from one installation to another. Some may have very extensive nighttime flying requirements where as others may have operations concentrated during the normal working day.

Any single military installation is likely to have much greater day-to-day variation in activities than would be found at civilian airports which have routine daily flight schedules. Non-routine noise exposures at military bases can be generated by regular training cycles, periodic readiness exercises, or special certification exercises. While there may be less nighttime activity than at most civilian airports on the average, there are also likely to be short periods of nighttime training or testing when there are very high levels of activity which occur after dark, either in the evening or at night. Since the purpose of most nighttime activity is primarily to provide experience in flying after dark, it is likely that this activity will actually occur in the evening hours, especially during the winter months.

Detailed data have not been gathered about the opeations at different military bases. The information which is readily available for the Navy and Air Force is described in this report.

Data on Aircraft Operations at Naval Bases

Information about aircraft operations at Navy and Marine Corps air facilities has been gathered as part of the Navy's Air Installations Compatible Use Zones (AICUZ) program. The program is designed to meet the requirements of the "Noise control Act of 1972". The purpose of the AICUZ program is "to ensure that development of impacted lands will be compatible with the noise levels, accident potential and flight clearance requirements associated with military airfield operations". The program thus is focused on assisting the local command in attempts to preclude incompatable development around military airfields. Though the program is not primarily a data gathering exercise, some useful data have been gathered.

AICUZ studies have been completed at about 75 airfields, including all the major airfields. The location of Naval and Marine Corps air facilities are given on maps in appendix D.

All AICUZ studies have provided a noise contour map and some basic information about the aircraft operations at the air facility. Most of the studies also include a land use map. The data from the AICUZ studies have been consolidated in a standard format.

The noise contour map is based on the levels which are predicted from the NOISEMAP aircraft noise prediction computer program. The NOISEMAP predictions are based on data the air facility personnel were able to obtain from routine records and from familiarity with local operations. No special noise measurements or other observations of aircraft operations are required by the program. The three noise zones delineated on the noise contour map are given in table V. In older studies the NEF and CNR descriptors were used. Since 1978 the LDN descriptor has been used in all locations except California where the CNEL descriptor is used.

The AICUZ report contains information on a rather large number of items, many of which are related more to safety than to noise issues. (Appendix E contains the relevant form.) The primary information which is most likely to be relevant for time-of-day operation studies is the following:

(1) Total number of aircraft operations annually
(2) Proportion of operations by fixed-wing and by rotary-wing aircraft
(3) Proportion of operations in the daytime and nighttime
(4) Proportion of total operations at the airfield for each runway heading
(5) The types of aircraft which are based at the facility or use it on an itinerate basis
(6) Whether or not two types of special operations are performed: Fleet Carrier Landing Practices (FCLP) or Fleet Mirror Landing Practices (FMLP)

The definition of nighttime operations may not always have been uniform in the past. The data which is now being collected utilizes the standard LDN definition of nighttime (2200 to 0700) which is based on the concept of nighttime as the sleeping period. Some early studies have been found to have been based on an after-dark definition, a concept which comes from the operational requirements for certain numbers of nighttime (i.e., after-dark) operations. It would be necessary to make further checks before determining what definition of nighttime was used for early studies.

The presence of FCLP or FMLP exercises means that there are periodically sets of days with unusually large numbers of operations. They may last several days or several weeks. They almost always include sizeable proportions of after-dark operations.

The land-use maps can be expected to include a residential category. Information about the numbers of people residing within different noise contours is not routinely tabulated. the other parts of the AICUZ planning exercise routinely include data on acreage rather than numbers of people impacted.

Data on Aircraft Operations at Air Force Bases

The Air Force has also conducted AICUZ studies. NOISEMAP is used to prepare noise contour maps for all the AICUZ studies. These studies have been completed at about 120 Air Force Bases and auxiliary fields. The complete set of input data for NOISEMAP are available at a single location (Air Force Engineering and Services Center, Tyndall AFB). There does not appear to be any easily available data in a standard format which provides information about the relative amount of nighttime and daytime flying. Noise contours are available in LDN. Routing reports in the early 1980's did give acerage within each contour but did not provide information about numbers of residences.

The different types of missions at different bases mean that the types of aircraft differ considerably from base to base. Operations also vary considerably from base to base, but it appears that no one type of operation or mission generates a large number of night flights. There are some auxiliary fields which do not have lights and thus do not have night flights. These are unusual and often lightly used airfields. In some cases they are used mainly for touch-and-go and other operations. In attempts to reduce community impact it is possible that nighttime flying may be concentrated at bases where there are not sensitive nearby civilian communities.

Implications for Study Design

The variety of military missions and the central control which is exercised over operations at military airports would appear to present some possibilities for finding or creating required variations in noise environments at different times of day for short periods of time. This type of short-term variation is less likely to be available at civilian airports. The logistics of locating possible study airfields is simplified for military airfields because of centrally located data bases. The required verification of the centrally located data might also be relatively economically accomplished.

Other aspects of military locations make them less attractive as possible study areas. The standard concern about the effects of community attitudes toward the military generally is of course important, though it is not addressed by the present data. The information reviewed does however point to the fact that the military operations are likely to differ from civilian operations in three respects which are directly related to time-of-day issues: (1) there are relatively few weekend operations on a routine basis (with the possible exception of some Air National Guard locations) (2) there are likely to be occasional periods of unusually high numbers of operations (3) there may well be very small numbers of operations during the conventional nighttime sleeping period.

On the balance the information which has been examined to date appears to indicate that military installations do not provde a suitable long-term, average noise environment for drawing conclusions about nighttime noise reactions around civilian airports. A definite decision about the feasibility of any particular study design would, however, need to be based on a more detailed examination of specific military airfields.

CONCLUSIONS

Information about noise environments at different times of day is aggregated to the airport level in the Official Airline Guide computerized data files. Information at selected sites around some airports is available from permanent noise monitoring locations. Only very limited data on the timing of flights are available at centralized locations for military airports.

Noise measurement data from permanent noise monitoring sites can provide information about daytime and nighttime aircraft noise levels at particular locations around airports. In this report 6009 days of data from 128 permanent noise monitoring sites at 11 airports are examined. Differences between daytime and nighttime noise levels at these 128 noise monitoring sites vary from 3 to 17 dB(A), LEQ.

The OAG and noise monitoring data are compared for nine airports. While the data are not usually inconsistent, it is found that the correlation between the measures of day-night differences derived from the two data sets is no more than r=0.60. The noise monitoring data show that day-night noise level differences can vary considerably between different sites at the same airport.

Some information about movements of aircraft has been collected as part of Air Installations Compatible Use Zones (AICUZ) programs. Some data are available at central locations for both Navy and Air Force flight facilities. Limited information about the timing of flights is readily available for Naval facilities, but more detailed information about the distribution of flights for particular flight paths is not available centrally. The Air Force has detailed data about the timing of aircraft movements stored on computer tapes in a central location, but the data are not aggregated to provide information about noise environments at different times of day.

Preliminary analyses suggest that accurate estimates of the time-of-weights used in environmental noise indices could not be obtained from conventional social surveys at existing airports.

APPENDIX A

CALCULATIONS FOR PREDICTING THE VARIANCE OF ESTIMATES OF NIGHTTIME WEIGHTS FOR ALTERNATIVE STUDY DESIGNS

A method is required for predicting the approximate variance of the nighttime weighting which can be expected for different sample designs. The conventional adjusted energy model which weights the effects of noise at different times of day is the following:

$$L_I = q + c \bullet 10 \bullet \log_{10}\left[(t_d \bullet 10^{LEQ_d/10} + t_n \bullet w_n \bullet 10^{LEQ_n/10})/24\right].$$

where q and c are constants, LEQ is the equivalent continuous noise level for either the day (LEQ_d) or night (LEQ_n), the length of the time period is t_d (for the daytime) or t_n (for the nighttime and w_n is the nighttime weighting. The sampling distribution of w_n departs severely from the normal distribution, but this weight can be transformed into a new parameter, B_n, ($B_n = (w_n/(1+w_n))$) which does have an approximately normal sampling distribution. As a result the procedures in this paper are directed at first estimating B_n and the variance of B_n ($\sigma^2_{B_n}$) and then transforming the results to provide the estimates of the nighttime weight, w_n, and the confidence intervals for the estimate of the weight.

The quantity which is given the symbol B_n is labeled the nighttime regression coefficient. It can be interpreted as a partial regression coefficient for nighttime noise from nonlinear regression. The above equation can be rewritten in terms of a nonlinear regression equation:

$$L_I = q + c \bullet 10 \bullet \log_{10}\left[(t_d \bullet B_d \bullet 10^{LEQ_d/10} + t_n \bullet B_n \bullet 10^{LEQ_n/10})/24\right]$$

The value of the nighttime weight (w_n) can then be seen to be the ratio of the two partial regression coefficients:

$$w_n = B_n/B_d$$

It should also be noticed that since there are only two variables representing the noise level (LEQ_d and LEQ_n) but three slopes being estimated (c, B_d, B_n), the equation is over-identified and there is not a unique value for each of the parameters. When it is decided to combine two of the parameters in the above ratio, then a unique solution is possible. However, this means that the values of B_n and B_d or not independent of one another. The sum of these two coefficients must be a constant. As long as the signs for both of these partial regression coefficients is positive then the value of the ratio becomes large as B_n increases and B_d correspondingly decreases. As the value of B_d becomes infinitely small the value of the ratio becomes infinitely large.

If the sum of the partial regression coefficients is set to the arbitrary value of one ($B_d + B_n = 1$), then the equation can be written in terms of the nighttime regression coefficient (B_n) which is applied to the nighttime noise ($t_n \bullet 10^{LEQ_n}$) and the difference between the nighttime and daytime noise (DIF) which has a coefficient of one. This difference in the two noise levels (DIF) is defined as:

$$DIF = t_d \bullet 10^{LEQ_d/10} - t_n \bullet 10^{LEQ_n/10}$$

Two new quantities are now defined:

$$X = 10 \bullet \log_{10}(B_n \bullet DIF + t_d \bullet 10^{LEQ_d/10})$$

$$Y = 10 \bullet \log_{10}(e) \bullet B_I \bullet (DIF/(B_n \bullet DIF + t_d \bullet 10^{LEQ_d/10}))$$

In order to estimate the variance of the nighttime coefficient (B_n) for a new sample design, it is necessary to make assumptions about the variance of these two newly defined quantities (σ^2_X and σ^2_Y), their covariance (σ_{XY}), the expected sample size (m) and the residual (unexplained) variance (σ^2_e).

An asympotic approximation of the variance can be formed. For large sample sizes the distribution of the sampling distribution for B_n approaches the normal distribution. The prediction for the variance is:

$$\sigma^2 B_n = \sigma^2_e/m \bullet (\sigma^2_X/(\sigma^2_X \sigma^2_Y - (\sigma_{XY})^2))$$

Four of the parameters which enter into the estimate of this variance are study design variables: the sample size (m), the daytime noise exposure (LEQ_d), the nighttime noise exposure (LEQ_n) and the relationship between the two noise exposures.

Two of the other parameters depend upon characteristics of the human response to noise and would need to be estimated based on the findings from previous surveys (σ^2_e and B_I). The accuracy of a study estimate is directly proportional to the ratio of square of the regression coefficient for a noise index and the residual variance (B^2_I/σ^2_e). Ten surveys of community response to noise were examined. A total of thirty-five measures of annoyance were analyzed. For each annoyance measure the critical ratio was estimated (B^2_I/σ^2_e). The best ratio (i.e., ratio which would yield the most accurate estimate) was identified for each survey. The best estimate from one survey was substantially worse than that from any other survey. This survey was excluded. To be conservative, the survey which provided the next worst estimate was identified. The calculations in this report were then based on that survey. The estimate of the total noise level regression coefficient is B_I=.0803 and the estimate of the residual error variance is σ^2_e=3.5474.

The variance also depends upon the true value of the time-of-day weight. The greater the actual value of the weight, the higher the variances of the estimates and the more difficult it is to obtain a precise estimate of the weight. For the calculations presented in this report the value of the nighttime weight is assumed to be w_n=10. Thus the value of the nighttime regression coefficient is B_n=0.91. (If $B_n + B_d = 1$ and w_n=10 then $B_n/(1-B_n)$=10 and B_n=0.91).

The estimates presented in this report are based on simple random sampling assumptions. Thus it is assumed that any differences in reactions at the different airports will be entirely explained by differences in noise levels or distributions of daytime and nighttime noise levels. Previous research has found that there are airport differences which can substatially reduce the precision of the surveys (Fields, 1984: p.451). On the basis of past experience it is quite possible that sample size requirements are underestimated by 50% using the simple random sample assumptions implicit in the present report.

APPENDIX B

DETAILED NOISE MONITORING SITE INFORMATION

TABLE B-1 NOISE ENVIRONMENTS AT MONITORING SITES

AIRPORT	SITE ID NUMBER	LEQ 24 HR	DAY LEQ (12 HR)	EVENING LEQ (3 HR)	NIGHT LEQ (9 HR)	DAY LEQ (15 HR) MINUS NIGHT	DAY LEQ (12 HR) MINUS EVENING	DAYS OF DATA
WASH NATL	101	56.5	58.7	57.5	44.5	13.9	1.1	52
	102	65.8	68.1	65.6	52.7	15.0	2.5	52
	103	63.7	65.6	65.2	55.0	10.5	.4	52
	104	67.8	69.8	69.1	57.2	12.5	.8	52
	105	58.0	60.0	59.4	46.5	13.4	.7	52
	106	67.2	69.3	68.6	56.2	12.9	.6	52
	107	60.7	61.9	64.2	52.1	10.3	-2.2	51
	108	50.2	52.2	51.4	41.7	10.4	.9	52
	109	64.1	65.9	65.7	57.0	8.9	.2	51
	110	57.3	59.4	58.4	45.3	14.0	1.0	52
	111	55.7	57.7	57.1	45.7	11.9	.7	52
	112	68.6	70.6	69.7	59.5	11.0	1.0	47
	113	64.7	66.7	66.2	54.4	12.2	.6	51
	114	64.1	66.1	65.4	52.3	13.7	.7	49
	115	59.9	62.0	53.3	56.4	4.7	8.7	52
MEAN		61.63	63.612	62.450	51.763	11.699	1.161	49.5
STD DEV		5.262	5.278	5.825	5.578	2.573	2.285	
SAN JOSE	201	58.8	61.0	59.1	48.9	11.8	1.9	98
	202	64.5	66.3	65.5	58.4	7.8	.8	190
	203	72.9	74.7	74.3	65.8	8.7	.4	190
	204	61.5	63.7	60.9	53.3	9.9	2.8	190
	205	58.4	60.7	57.2	49.1	11.1	3.5	190
	206	63.0	65.3	62.6	52.8	12.1	2.7	127
	207	77.2	79.7	74.9	67.0	12.1	4.8	98
	208	66.6	68.8	66.4	57.7	10.7	2.5	119
	209	62.5	65.0	61.1	50.7	13.7	3.8	98
	210	69.7	72.2	67.4	59.9	11.7	4.7	179
	211	64,9	67.4	62.2	54.2	12.6	5.3	158
	212	63.2	65.9	59.5	49.6	15.6	6.4	98
MEAN		65.26	67.554	64.254	55.606	11,492	3.301	145.
STD DEV		5.582	5.570	5.693	6.238	2.091	1.812	
JOHN WAYNE	301	65.1	67.6	64.7	49.3	17.9	2.9	61
	302	56.9	59.5	55.2	39.1	19.9	4.3	61
	303	55.1	57.7	53.0	38.5	18.6	4.8	61
	304	61.1	62.8	63.2	52.2	10.7	-.4	61
	305	48.4	50.3	49.3	41.9	8.2	1.0	61
	306	66.7	69.2	65.6	51.7	17.0	3.6	61
	307	66.3	68.8	65.6	52.4	16.0	3.1	61
	308	59.0	61.6	57.1	42.1	18.9	4.5	61
	309	49.0	49.9	49.6	47.0	2.8	.4	60
MEAN		58.64	60.831	58.166	46.028	14.427	2.665	60.9
STD DEV		6.928	7.281	6.787	5.686	5.871	1.907	

AIRPORT	SITE ID NUMBER	LEQ 24 HR	DAY LEQ (12 HR)	EVENING LEQ (3 HR)	NIGHT LEQ (9 HR)	DAY LEQ (15 HR) MINUS NIGHT	DAY LEQ (12 HR) MINUS EVENING	DAYS OF DATA
SEATTLE	401	68.0	69.5	68.8	64.0	5.4	.6	5
	402	67.0	68.6	67.4	62.8	5.5	1.2	5
	403	70.3	71.8	70.8	66.2	5.4	1.0	5
	404	79.0	80.2	79.7	75.8	4.3	.6	5
	405	65.7	67.3	66.1	61.4	5.7	1.3	5
	406	78.0	79.8	78.9	72.4	7.2	.9	5
	407	70.0	71.8	70.1	65.4	6.0	1.7	5
	408	67.9	69.7	68.2	62.3	7.1	1.5	5
	409	68.6	70.8	67.6	62.0	8.2	3.2	5
MEAN		70.50	72.154	70.822	65.819	6.107	1.332	5.00
STD DEV		4.756	4.686	4.997	5.015	1.199	.784	
TORRENCE	501	56.7	59.2	55.3	44.2	14.5	3.9	50
	502	50.0	52.6	47.9	34.8	17.2	4.7	50
	503	48.6	50.7	49.0	39.9	10.5	1.7	50
	504	40.8	43.7	32.7	21.6	21.2	11.1	50
	505	53.3	55.6	51.7	45.8	9.3	3.9	50
	506	48.3	50.9	45.9	32.9	17.4	5.0	50
	507	45.0	47.5	43.8	33.4	13.6	3.7	50
	508	46.7	49.4	38.3	36.4	12.1	11.2	50
	509	50.7	53.1	50.0	39.2	13.5	3.1	50
	510	56.1	58.6	54.2	44.5	13.6	4.4	50
	511	53.9	56.3	52.7	43.0	12.8	3.7	50
MEAN		50.01	52.522	47.395	37.781	14.147	5.128	50.0
STD DEV		4.840	4.740	6.930	7.059	3.380	3.083	
SAN DIEGO	601	71,4	73.1	71.1	67.2	5.6	2.0	32
	606	71.6	73.8	71.0	64.4	9.0	2.8	32
	607	78.8	81.1	75.9	72.2	8.3	5.2	32
	608	78.3	80.2	77.6	73.1	6.7	2.6	32
	613	64.2	66.0	63.6	59.8	5.8	2.4	32
	614	63.7	65.7	61.4	59.2	6.0	4.3	32
	615	65.8	68.0	63.5	59.9	7.5	4.5	32
	616	67.5	69.7	65.4	61.5	7.6	4.3	32
	617	69.1	71.1	68.7	63.1	7.6	2.5	32
	618	65.1	67.0	65.1	59.4	7.3	1.9	32
	619	68.2	70.8	65.8	57.5	12.7	4.9	32
	620	62.6	64.2	63.4	58.0	6.1	.8	32
	621	65.9	68.1	63.8	59.6	8.0	4.4	32
	622	68.8	71.4	65.6	57.3	13.5	5.9	32
	623	62.1	63.2	61.4	60.3	2.6	1.9	32
MEAN		68.21	70.236	66.867	62.150	7.613	3.369	32.0
STD DEV		5.082	5.239	4.967	5.010	2.680	1.506	

AIRPORT	SITE ID NUMBER	LEQ 24 HR	DAY LEQ (12 HR)	EVENING LEQ (3 HR)	NIGHT LEQ (9 HR)	DAY LEQ (15 HR) MINUS NIGHT	DAY LEQ (12 HR) MINUS EVENING	DAYS OF DATA
LAX	731	80.9	82.7	81.1	75.8	6.6	1.6	28
	732	80.7	81.8	80.9	78.3	3.3	.9	28
	741	69.2	70.5	70.7	65.0	5.6	-.1	28
	742	64.5	65.9	66.1	59.8	6.2	-.2	28
	751	65.7	66.8	68.6	61.1	6.1	-1.8	28
	752	68.5	69.3	70.7	65.5	4.2	-1.4	28
	761	74.1	74.7	76.1	71.7	3.4	-1.3	28
	762	73.2	74.0	75.1	70.5	3.7	-1.1	28
	771	67.3	69.2	67.9	59.9	9.1	1.3	28
	772	65.9	67.3	67.6	60.8	6.6	-.2	28
	773	71.4	73.2	72.6	65.2	7.8	.6	28
	774	73.4	74.3	76.3	69.1	5.7	-2.1	28
MEAN		71.22	72.469	72.803	66.887	5.677	-.334	28.0
STD DEV		5.485	5.469	5.098	6.256	1.803	1.227	
ONTARIO, CAL.	801	68.3	68.4	71.2	66.5	2.6	-2.8	28
	802	67.4	70.1	64.2	52.3	17.1	5.8	28
	803	67.7	70.0	67.5	54.0	15.7	2.5	28
	804	70.4	73.1	68.1	55.1	17.3	5.0	28
	805	63.6	66.1	63.0	48.2	17.4	3.1	28
	806	56.7	59.2	55.8	44.1	14.5	3.3	28
	807	63.5	64.7	63.6	60.9	3.6	1.1	28
	808	66.3	66.4	69.6	63.8	3.4	-3.2	28
MEAN		65.49	67.239	65.384	55.628	11.449	1.855	28.0
STD DEV		4.244	4.227	4.856	7.705	6.903	3.343	
VAN NUYS	901	61,3	62.8	63.2	55.0	7.9	-.4	28
	902	63.7	65.9	64.1	52.0	13.6	1.8	28
	903	64.7	67.2	63.3	49.6	17.0	3.9	28
	904	61.2	63.6	60.7	48.7	14.5	2.9	28
MEAN		62.72	64.898	62.849	51.323	13.271	2.050	28.0
STD DEV		1.730	2.014	1.475	2.797	3.834	1.842	
SAN FRANCISCO	1001	70.1	72.1	71.1	61.7	10.2	1.0	33
	1002	55.0	56.9	56.7	45.4	11.4	.3	33
	1003	55.0	57.1	53.8	49.0	7.6	3.3	33
	1004	66.0	67.9	67.3	56.7	11.1	.7	33
	1005	63.6	65.5	65.6	54.3	11.2	-.2	33
	1006	61.7	63.6	63.4	52.4	11.1	.1	33
	1007	56.9	58.9	58.4	47.9	10.8	.5	33
	1008	65.3	66.6	67.1	60.9	5.8	-.5	33
	1009	57.4	58.8	58.4	53.3	5.5	.4	33
	1010	54.3	56.0	54.6	49.3	6.5	1.4	33

AIRPORT	SITE ID NUMBER	LEQ 24 HR	DAY LEQ (12 HR)	EVENING LEQ (3 HR)	NIGHT LEQ (9 HR)	DAY LEQ (15 HR) MINUS NIGHT	DAY LEQ (12 HR) MINUS EVENING	DAYS OF DATA
SAN FRANCISCO(CONT.)								
	1011	57.1	57.6	60.4	53.6	4.7	-2.8	33
	1012	56.4	57.4	59.1	52.0	5.8	-1.6	33
	1013	51.2	52.9	51.5	46.7	6.0	1.4	33
	1014	50.2	52.4	50.9	40.4	11.7	1.4	33
	1015	61.4	63.8	59.7	52.6	10.6	4.1	33
	1016	58.0	59.6	60.8	47.5	12.4	-1.2	33
	1017	58.1	60.0	59.9	48.1	11.8	.1	33
	1018	60.5	62.4	61.9	51.5	10.9	.5	33
	1019	56.7	58.8	58.0	44.8	13.8	.7	33
	1020	57.0	58.9	58.7	47.3	11.5	.2	33
	1021	51.6	53.9	50.7	43.2	10.2	3.2	33
	1022	58.7	60.4	60.1	52.7	7.6	.4	33
MEAN		58.29	60.070	59.461	50.521	9.472	.609	33.0
STD DEV		4.938	4.943	5.347	5.280	2.702	1.555	
BURBANK	1101	70.9	73.1	71.3	60.9	11.9	1.8	44
	1102	66.7	68.8	67.7	55.5	13.1	1.1	44
	1103	66.0	68.2	66.6	54.8	13.2	1.6	44
	1104	67.0	69.0	68.0	57.9	10.9	1.0	44
	1105	68.4	70.6	68.5	57.8	12.5	2.1	44
	1106	66.8	68.9	65.1	61.7	6.7	3.8	44
	1107	64.4	66.4	64.1	57.7	8.4	2.3	44
	1108	60.5	62.2	60.9	55.5	6.4	1.3	44
	1109	62.4	64.1	63.4	57.3	6.6	.6	44
	1110	66.0	67.6	67.4	60.5	7.1	.3	44
	1111	66.3	67.9	67.8	60.9	6.9	.0	44
MEAN		65.95	67.888	66.447	58.222	9.429	1.441	44.0
STD DEV		2.792	2.952	2.859	2.429	2.863	1.052	
TOTAL MEAN		63.13	65.066	63.127	54.711	10.101	1.939	46.7
STD DEV		7.643	7.524	8.256	9.701	4.201	2.385	

TABLE B-2 VALUES OF NOISE INDICES AT MONITORING SITES

AIRPORT	SITE ID NUMBER	24 HOUR LEQ	LDN	CNEL	LDN MINUS LEQ (24 HR)	CNEL MINUS LEQ (24 HR)	DAYS OF DATA
WASH NATL	101	56.5	57.4	58.4	.8	1.8	52
	102	65.8	66.4	67.3	.7	1.5	52
	103	63.7	65.3	66.3	1.6	2.6	52
	104	67.8	68.9	69.9	1.1	2.1	52
	105	58.0	58.9	60.0	.9	2.0	52
	106	67.2	68.3	69.3	1.0	2.1	52
	107	60.7	62.4	63.8	1.7	3.1	51
	108	50.2	51.9	52.8	1.7	2.5	52
	109	64.1	66.3	67.2	2.2	3.0	51
	110	57.3	58.1	59.2	.8	1.9	52
	111	55.7	57.0	58.0	1.3	2.2	52
	112	68.6	70.1	71.0	1.5	2.4	47
	113	64.7	65.9	66.9	1.2	2.2	51
	114	64.1	64.9	66.0	.9	1.9	49
	115	59.9	63.9	64.0	4.0	4.1	52
MEAN		61.629	63.054	63.992	1.425	2.364	49.53
STD DEV		5.262	5.247	5.236	.825	.643	
SAN JOSE	201	58.8	60.1	60.9	1.3	2.1	98
	202	64.5	67.1	67.8	2.6	3.3	190
	203	72.9	75.1	75.9	2.2	3.0	190
	204	61.5	63.3	63.9	1.8	2.4	190
	205	58.4	59.8	60.4	1.5	2.0	190
	206	63.0	64.2	64.9	1.2	1.9	127
	207	77.2	78.4	78.9	1.2	1.7	98
	208	66.6	68.2	68.8	1.6	2.2	119
	209	62.5	63.4	64.0	.9	1.5	98
	210	69.7	71.0	71.4	1.3	1.8	179
	211	64.9	66.0	66.4	1.1	1.5	158
	212	63.2	63.8	64.2	.6	1.0	98
MEAN		65.257	66.692	67.286	1.435	2.029	144.6
STD DEV		5.582	5.699	5.689	.554	.648	
JOHN WAYNE	301	65.1	65.5	66.3	.4	1.2	61
	302	56.9	57.2	57.8	.2	.9	61
	303	55.1	55.4	56.0	.3	.9	61
	304	61.1	62.7	63.8	1.6	2.7	61
	305	48.4	50.9	51.6	2.4	3.1	61
	306	66.7	67.1	67.8	.4	1.2	61
	307	66.3	66.9	67.6	.5	1.3	61
	308	59.0	59.3	59.9	.3	.9	61
	309	49.0	54.0	54.4	5.0	5.4	60
MEAN		58.640	59.883	60.581	1.244	1.942	60.89
STD DEV		6.928	5.957	6.060	1.589	1.523	

AIRPORT	SITE ID NUMBER	24 HOUR LEQ	LDN	CNEL	LDN MINUS LEQ (24 HR)	CNEL MINUS LEQ (24 HR)	DAYS OF DATA
SEATTLE	401	68.0	71.7	72.2	3.7	4.2	5
	402	67.0	70.6	71.1	3.6	4.1	5
	403	70.3	73.9	74.4	3.6	4.1	5
	404	79.0	83.2	83.6	4.2	4.7	5
	405	65.7	69.2	69.7	3.5	4.0	5
	406	78.0	80.9	81.5	2.8	3.5	5
	407	70.0	73.4	73.9	3.4	3.8	5
	408	67.9	70.8	71.3	2.9	3.4	5
	409	68.6	71.0	71.5	2.4	2.9	5
MEAN		70.497	73.848	74.360	3.351	3.863	5.00
STD DEV		4.756	4.878	4.891	.548	.528	
TORRENCE	501	56.7	57.5	58.1	.7	1.4	50
	502	50.0	50.4	51.0	.4	1.0	50
	503	48.6	50.2	51.0	1.6	2.4	50
	504	40.8	41.0	41.2	.2	.3	50
	505	53.3	55.4	55.8	2.0	2.5	50
	506	48.3	48.7	49.2	.4	.9	50
	507	45.0	45.9	46.5	.9	1.5	50
	508	46.7	47.9	48.0	1.2	1.3	50
	509	50.7	51.6	52.3	.9	1.6	50
	510	56.1	57.0	57.5	.9	1.4	50
	511	53.9	54.9	55.5	1.1	1.7	50
MEAN		50.011	50.956	51.467	.945	1.456	50.00
STD DEV		4.840	5.048	5.149	.543	.613	
SAN DIEGO	601	71.4	75.0	75.4	3.6	4.0	32
	606	71.6	73.8	74.3	2.1	2.7	32
	607	78.8	81.2	81.5	2.4	2.7	32
	608	78.3	81.3	81.8	3.1	3.5	32
	613	64.2	67.6	68.1	3.5	3.9	32
	614	63.7	67.1	67.4	3.4	3.7	32
	615	65.8	68.5	68.9	2.7	3.0	32
	616	67.5	70.1	70.5	2.7	3.0	32
	617	69.1	71.8	72.3	2.7	3.2	32
	618	65.1	67.9	68.4	2.8	3.3	32
	619	68.2	69.3	69.8	1.1	1.5	32
	620	62.6	66.0	66.5	3.4	3.9	32
	621	65.9	68.4	68.8	2.5	2.9	32
	622	68.8	69.7	70.1	.9	1.3	32
	623	62.1	67.2	67.5	5.1	5.4	32
MEAN		68.213	71.001	71.410	2.788	3.198	32.00
STD DEV		5.082	4.837	4.836	1.008	.986	

AIRPORT	SITE ID NUMBER	24 HOUR LEQ	LDN	CNEL	LDN MINUS LEQ (24 HR)	CNEL MINUS LEQ (24 HR)	DAYS OF DATA
LAX	731	80.9	84.0	84.5	3.1	3.6	28
	732	80.7	85.4	85.8	4.7	5.1	28
	741	69.2	72.8	73.4	3.6	4.2	28
	742	64.5	67.8	68.4	3.3	4.0	28
	751	65.7	69.1	69.9	3.3	4.2	28
	752	68.5	72.8	73.4	4.3	4.9	28
	761	74.1	78.7	79.3	4.7	5.2	28
	762	73.2	77.7	78.3	4.5	5.1	28
	771	67.3	69.3	70.1	2.1	2.8	28
	772	65.9	69.0	69.7	3.1	3.8	28
	773	71.4	74.0	74.7	2.6	3.3	28
	774	73.4	76.9	77.8	3.5	4.4	28
MEAN		71.217	74.793	75.444	3.575	4.227	28.00
STD DEV		5.485	5.877	5.776	.841	.768	
ONTARIO, CAL.	801	68.3	73.4	74.0	5.1	5.7	28
	802	67.4	67.8	68.3	.4	.9	28
	803	67.7	68.3	69.1	.6	1.4	28
	804	70.4	70.8	71.4	.4	.9	28
	805	63.6	64.0	64.8	.4	1.2	28
	806	56.7	57.5	58.1	.7	1.4	28
	807	63.5	68.0	68.4	4.6	5.0	28
	808	66.3	70.9	71.7	4.7	5.4	28
MEAN		65.486	67.602	68.228	2.115	2.741	28.00
STD DEV		4.244	4.957	4.924	2.217	2.184	
VAN NUYS	901	61.3	63.8	64.7	2.5	3.4	28
	902	63.7	64.6	65.4	.9	1.8	28
	903	64.7	65.1	65.8	.4	1.1	28
	904	61.2	62.0	62.7	.7	1.5	28
MEAN		62.716	63.869	64.657	1.152	1.940	28.00
STD DEV		1.730	1.362	1.364	.937	1.004	
SAN FRANCISCO	1001	70.1	71.9	72.7	1.7	2.6	33
	1002	55.0	56.4	57.4	1.4	2.4	33
	1003	55.0	57.7	58.1	2.7	3.1	33
	1004	66.0	67.4	68.4	1.5	2.4	33
	1005	63.6	65.1	66.2	1.4	2.5	33
	1006	61.7	63.2	64.2	1.5	2.5	33
	1007	56.9	58.5	59.4	1.5	2.5	33
	1008	65.3	68.7	69.4	3.5	4.2	33
	1009	57.4	61.0	61.6	3.6	4.2	33
	1010	54.3	57.4	58.0	3.1	3.7	33

AIRPORT	SITE ID NUMBER	24 HOUR LEQ	LDN	CNEL	LDN MINUS LEQ (24 HR)	CNEL MINUS LEQ (24 HR)	DAYS OF DATA
SAN FRANCISCO(CONT.)							
	1011	57.1	61.1	61.9	4.0	4.8	33
	1012	56.4	59.9	60.7	3.5	4.3	33
	1013	51.2	54.6	55.1	3.4	3.9	33
	1014	50.2	51.5	52.4	1.3	2.1	33
	1015	61.4	63.0	63.5	1.6	2.1	33
	1016	58.0	59.1	60.5	1.2	2.5	33
	1017	58.1	59.4	60.4	1.3	2.4	33
	1018	60.5	62.0	63.0	1.5	2.5	33
	1019	56.7	57.6	58.6	.9	1.9	33
	1020	57.0	58.4	59.4	1.3	2.4	33
	1021	51.6	53.3	53.8	1.7	2.3	33
	1022	58.7	61.4	62.1	2.7	3.4	33
MEAN		58.290	60.390	61.223	2.101	2.934	33.00
STD DEV		4.938	4.905	4.939	.985	.854	
BURBANK	1101	70.9	72.2	73.0	1.3	2.1	44
	1102	66.7	67.7	68.6	1.0	2.0	44
	1103	66.0	67.0	67.9	1.0	1.9	44
	1104	67.0	68.5	69.4	1.5	2.4	44
	1105	68.4	69.5	70.3	1.1	1.9	44
	1106	66.8	69.9	70.2	3.1	3.4	44
	1107	64.4	66.7	67.3	2.4	2.9	44
	1108	60.5	63.7	64.2	3.2	3.7	44
	1109	62.4	65.5	66.2	3.1	3.7	44
	1110	66.0	68.9	69.6	2.9	3.6	44
	1111	66.3	69.3	70.0	3.0	3.7	44
MEAN		65.947	68.075	68.787	2.128	2.840	44.00
STD DEV		2.792	2.314	2.356	.948	.806	
TOTAL							
MEAN		63.127	65.206	65.878	2.080	2.752	46.74
STD DEV		7.643	8.149	8.117	1.289	1.223	

APPENDIX C

MAPS OF 11 AIRPORTS WITH PERMANENT NOISE MONITORING SITES

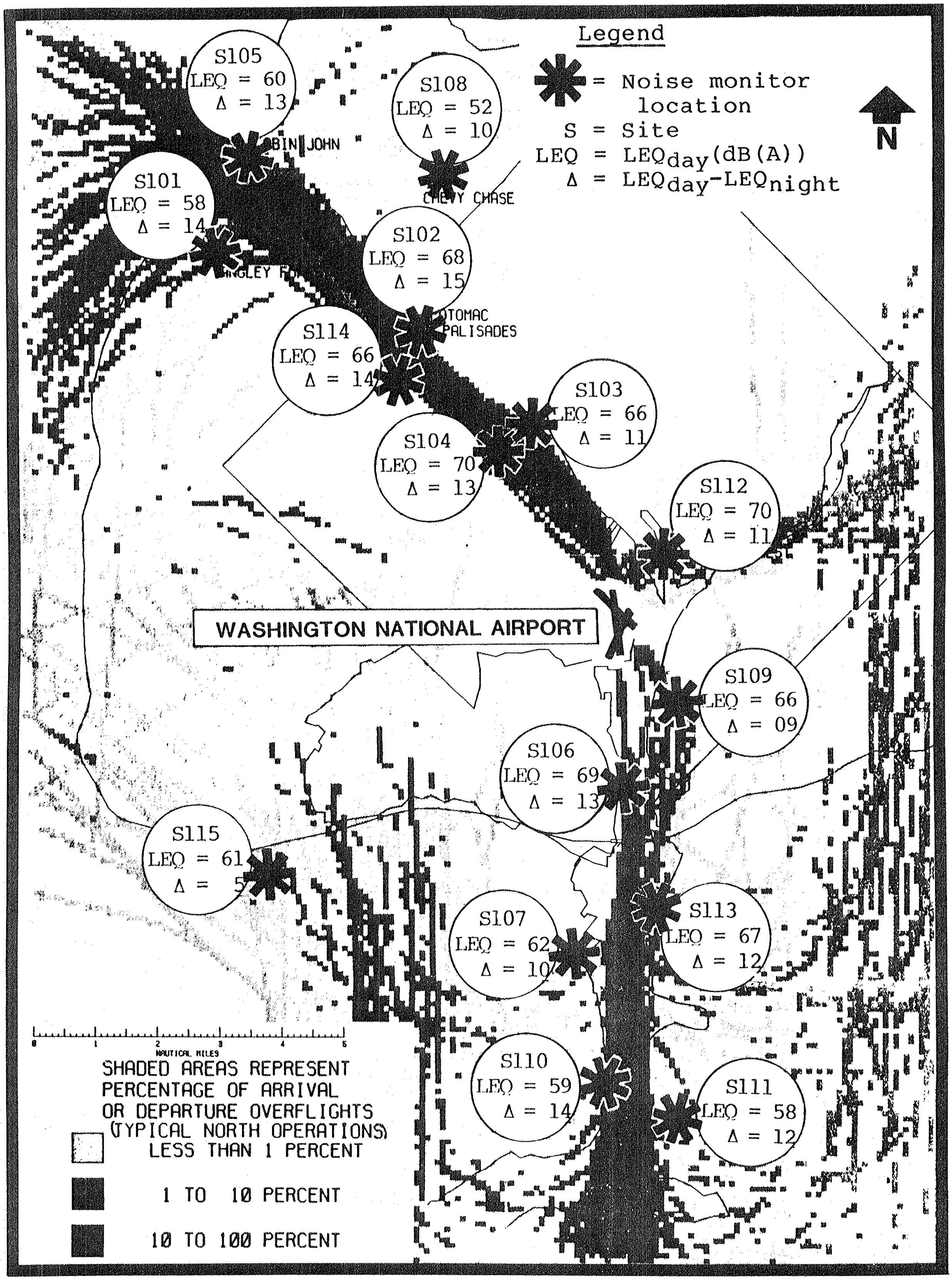

Figure C-1. Permanent noise monitoring sites: Washington National Airport (Washington D.C.)

Legend

= Noise monitor location
S = Site
LEQ = LEQ_{day} (dB(A))
Δ = $LEQ_{day}-LEQ_{night}$

1 mile

N

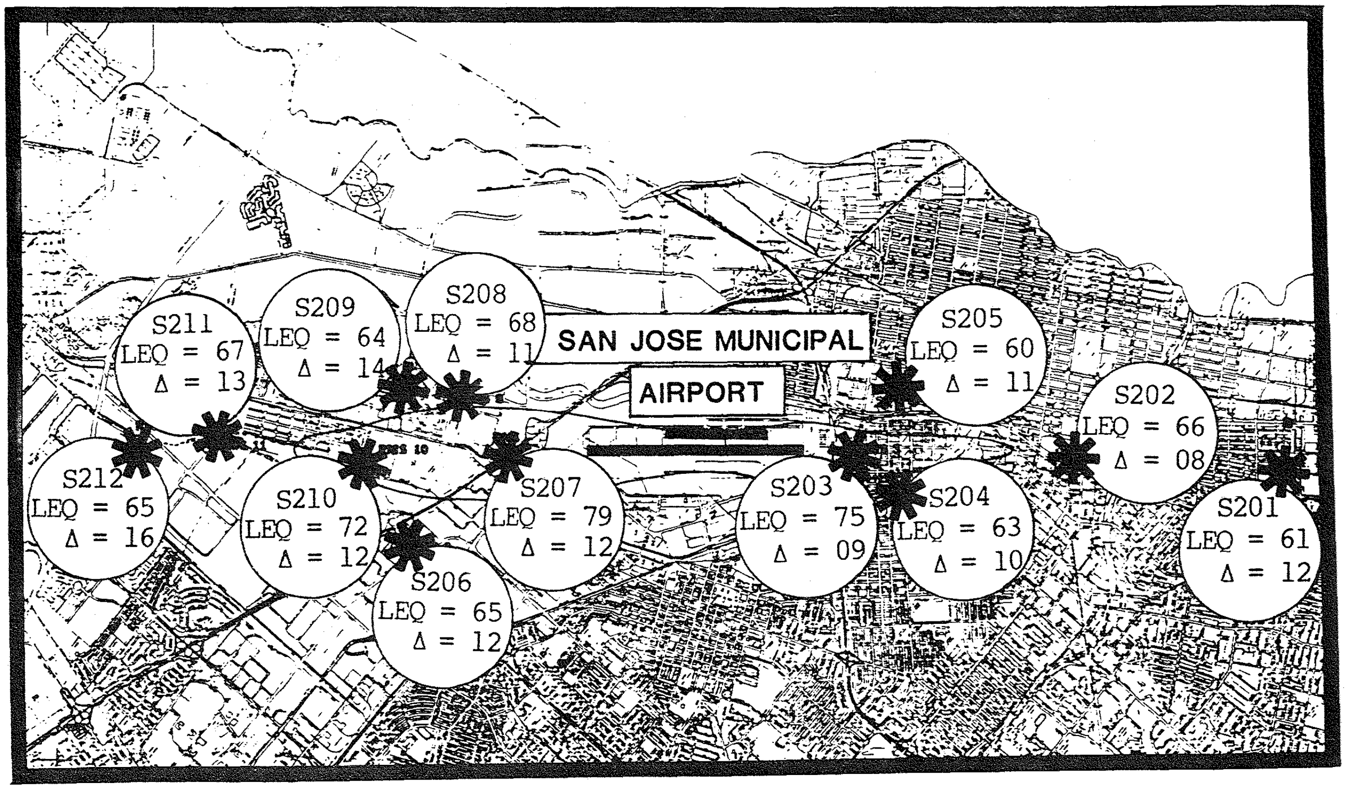

Figure C-2. Permanent noise monitoring sites: San Jose Municipal Airport (San Jose, Ca.)

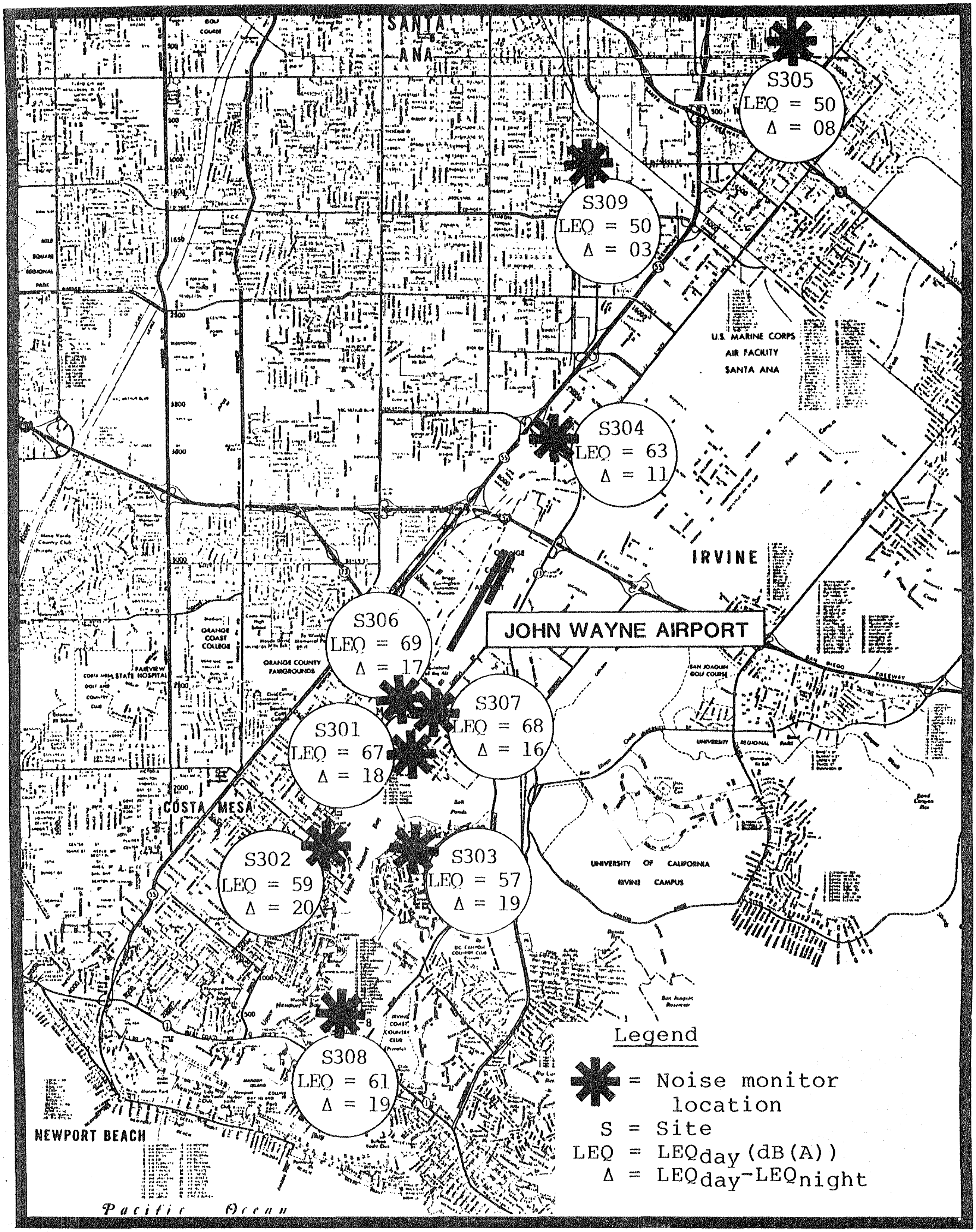

Figure C-3. Permanent noise monitoring sites: John Wayne Airport (Santa Ana, Ca.)

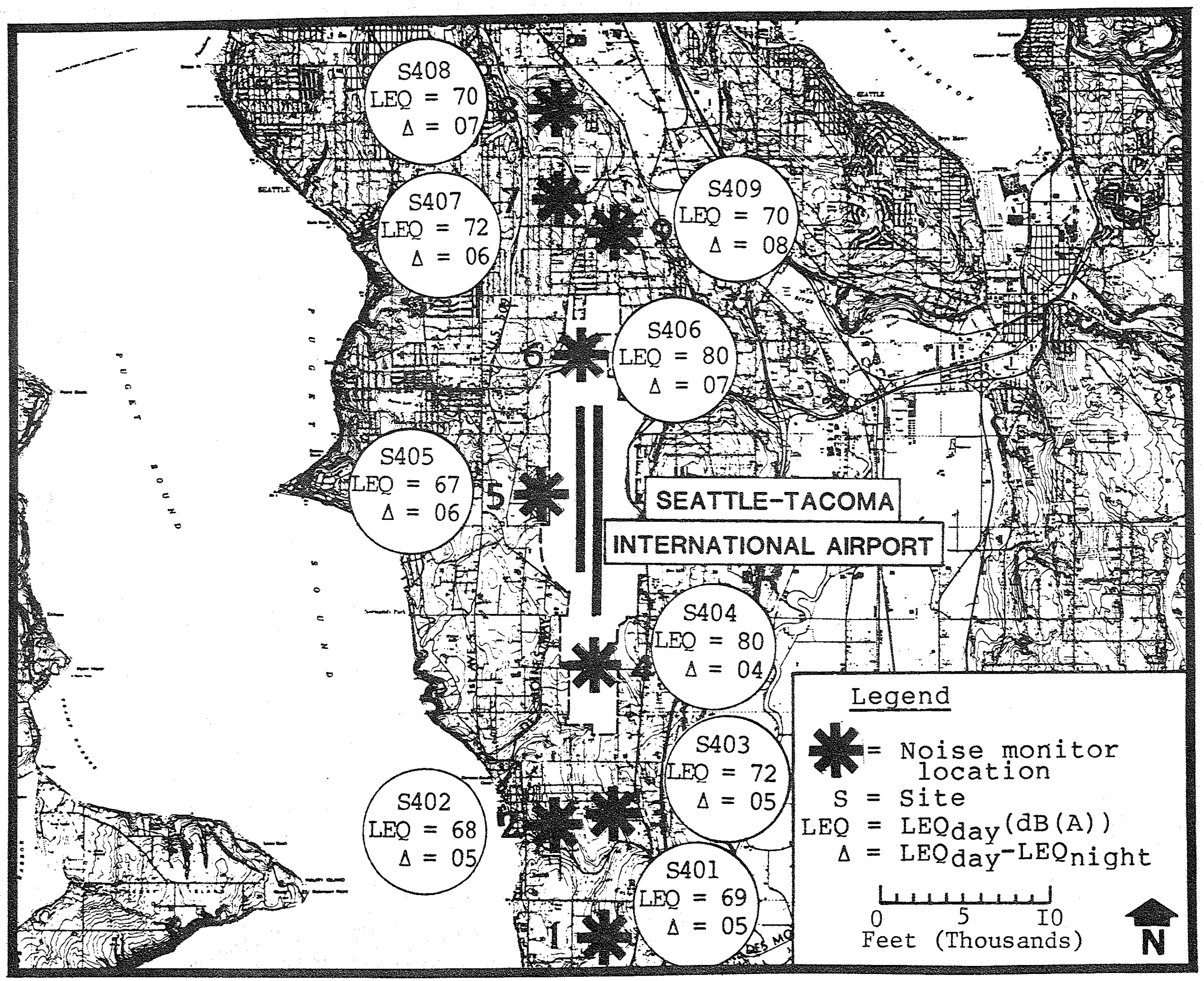

Figure C-4. Permanent noise monitoring sites: Seattle-Tacoma International Airport (Seattle, Wa.)

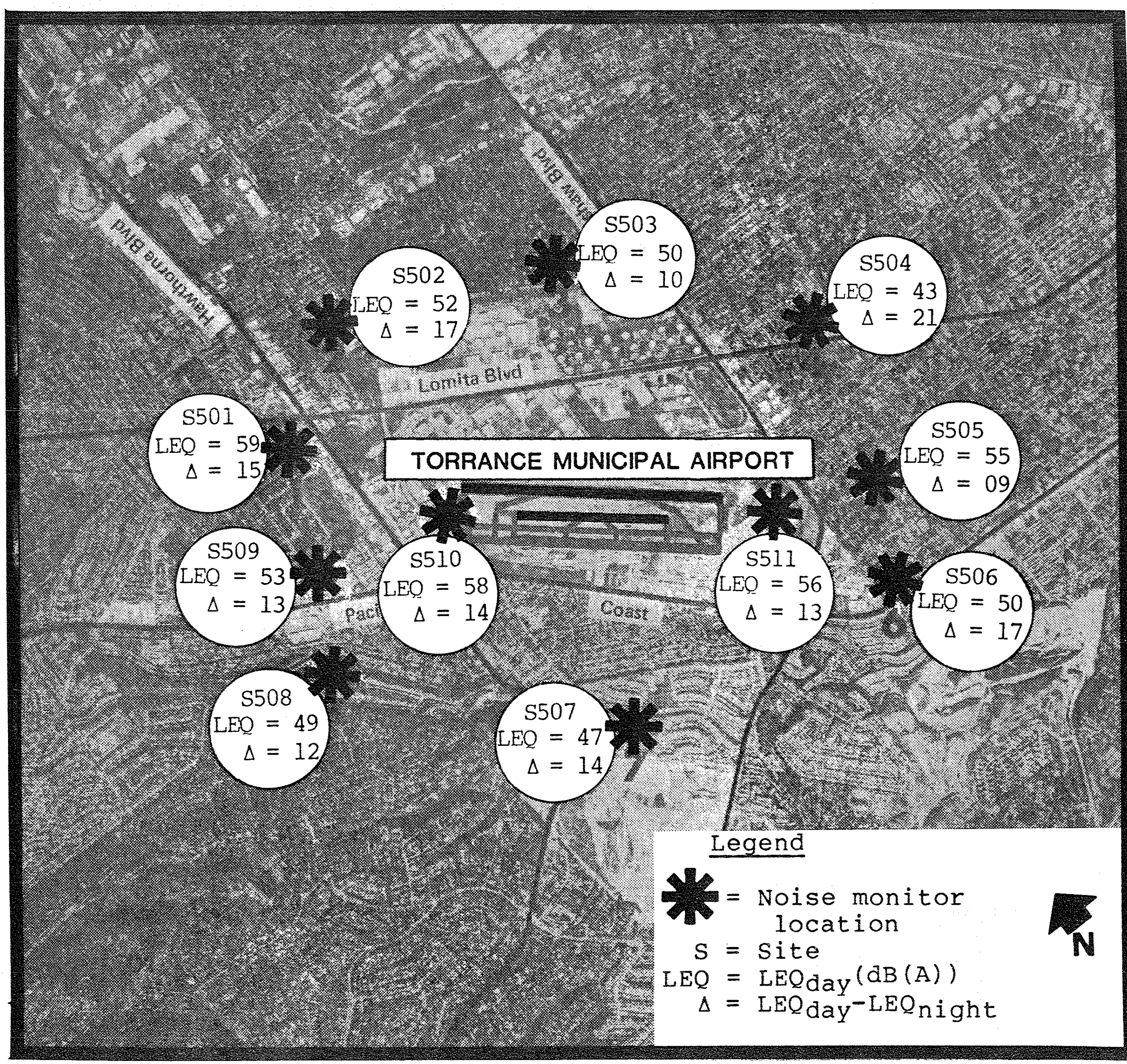

Figure C-5. Permanent noise monitoring sites: Torrance Municipal Airport (Torrance, Ca.)

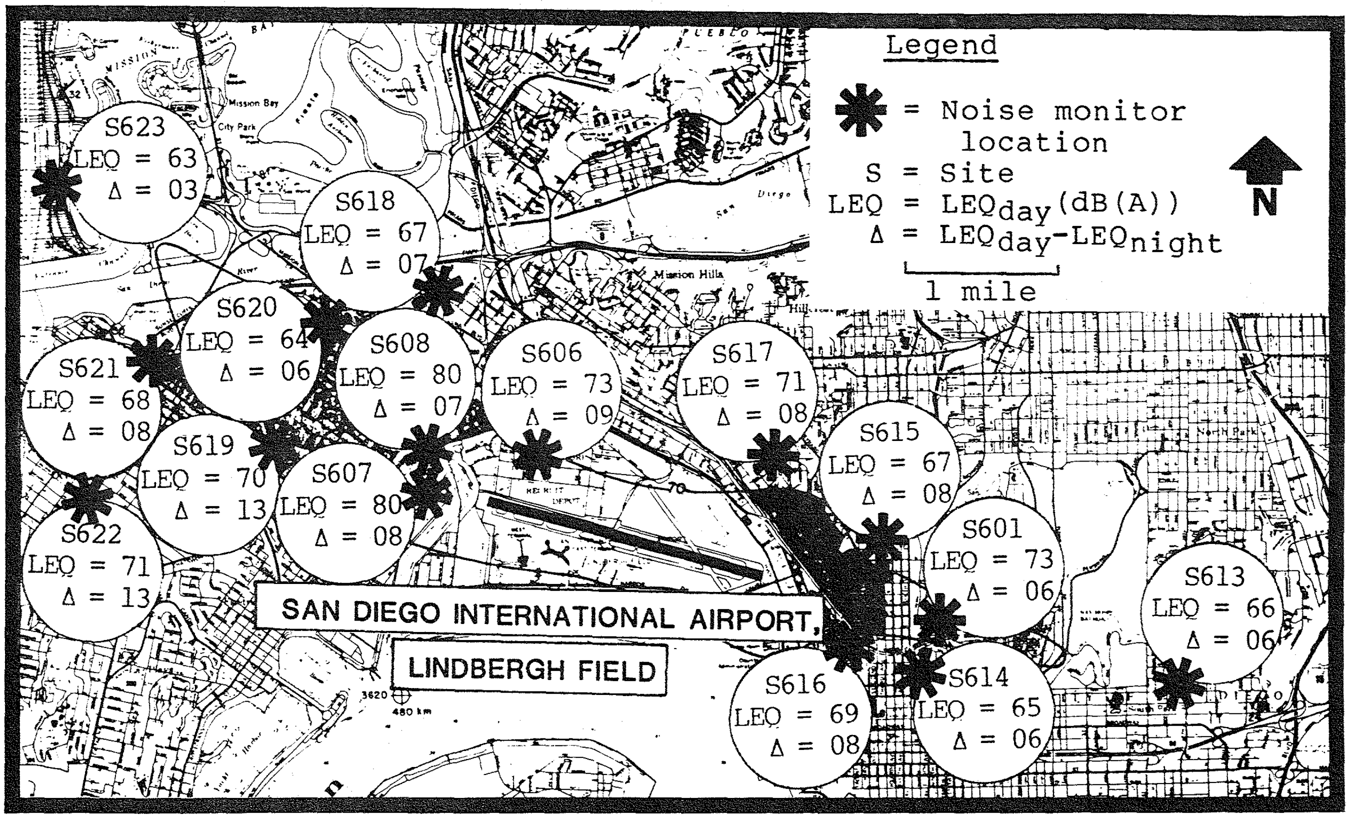

Figure C-6. Permanent noise monitoring sites: San Diego International Airport, Lindberg Field (San Diego, Ca.)

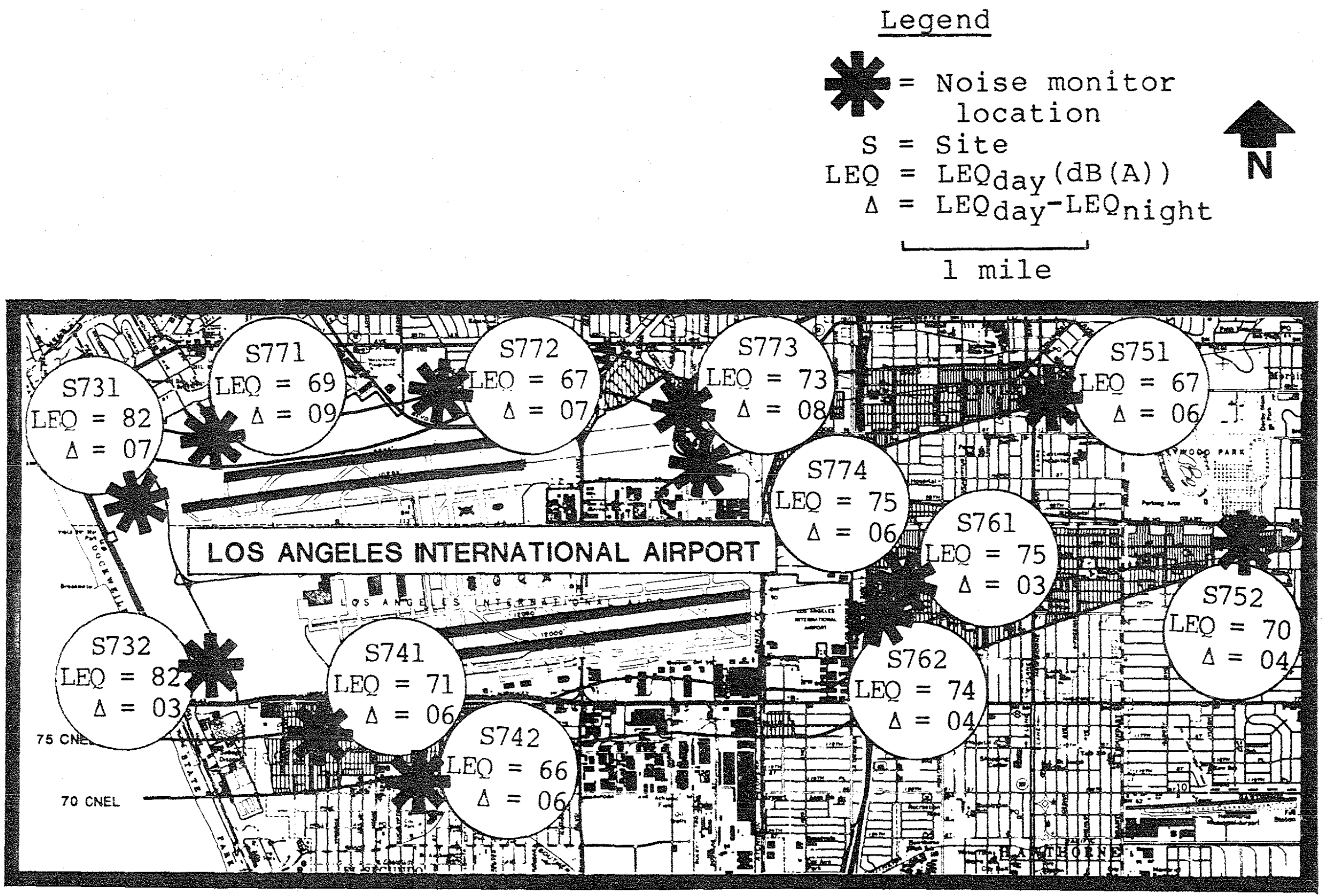

Figure C-7. Permanent noise monitoring sites: Los Angeles International Airport (Los Angeles, Ca.)

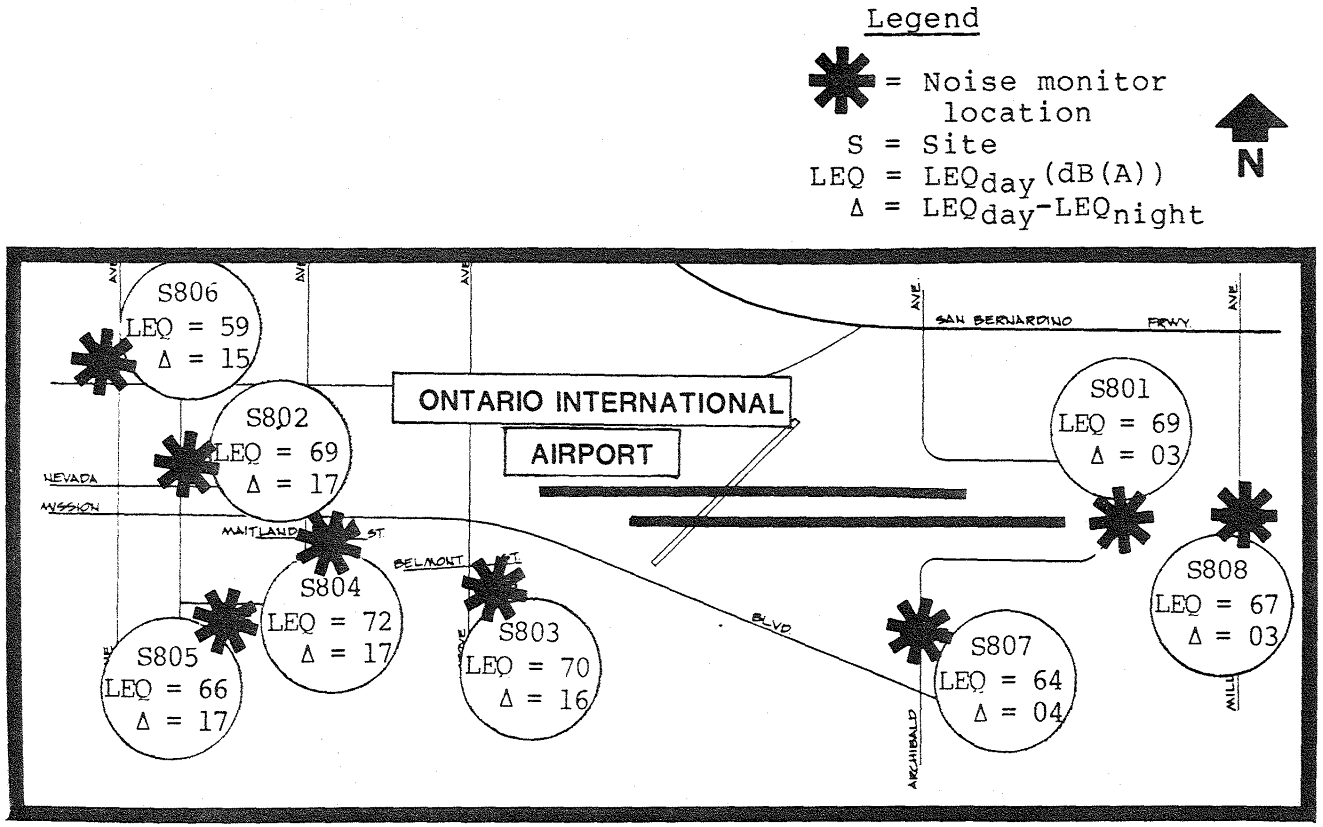

Figure C-8. Permanent noise monitoring sites: Ontario International Airport (Ontario, Ca.)

Legend

= Noise monitor location
S = Site
LEQ = LEQ_{day} (dB(A))
Δ = $LEQ_{day} - LEQ_{night}$

N

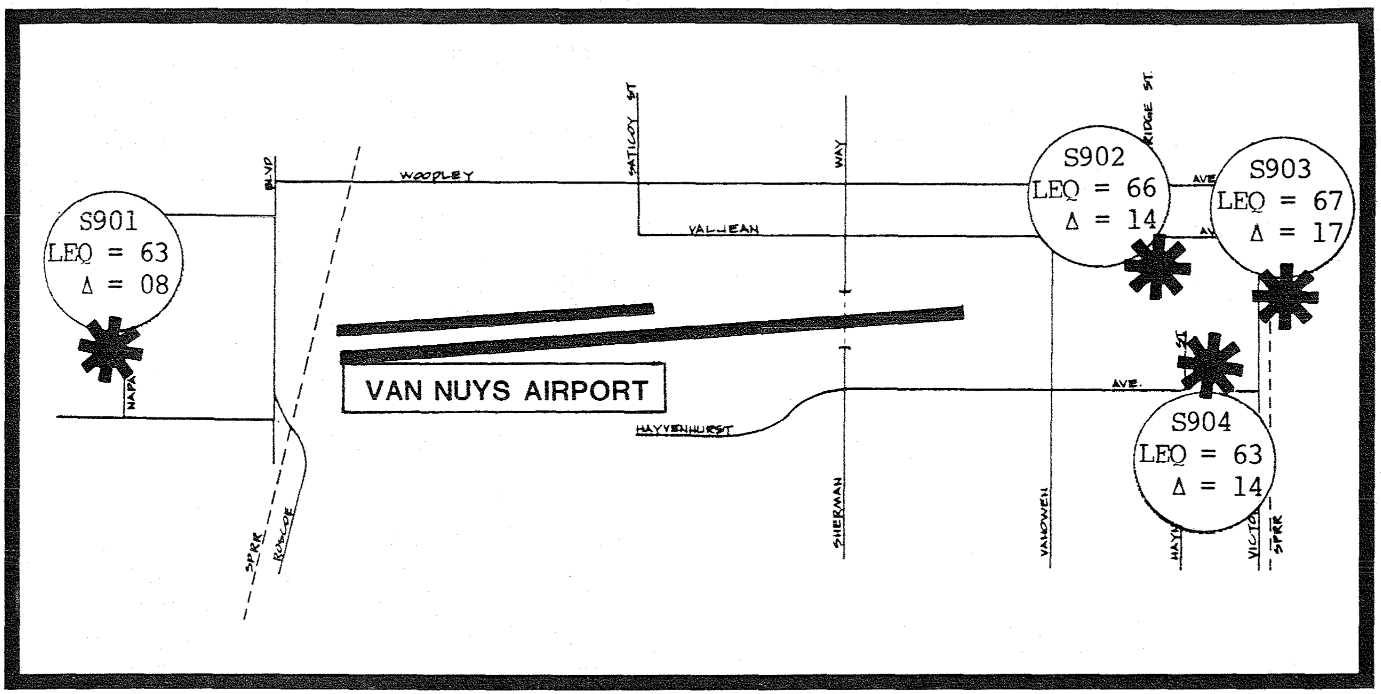

Figure C-9. Permanent noise monitoring sites: Van Nuys Airport (Van Nuys, Ca.)

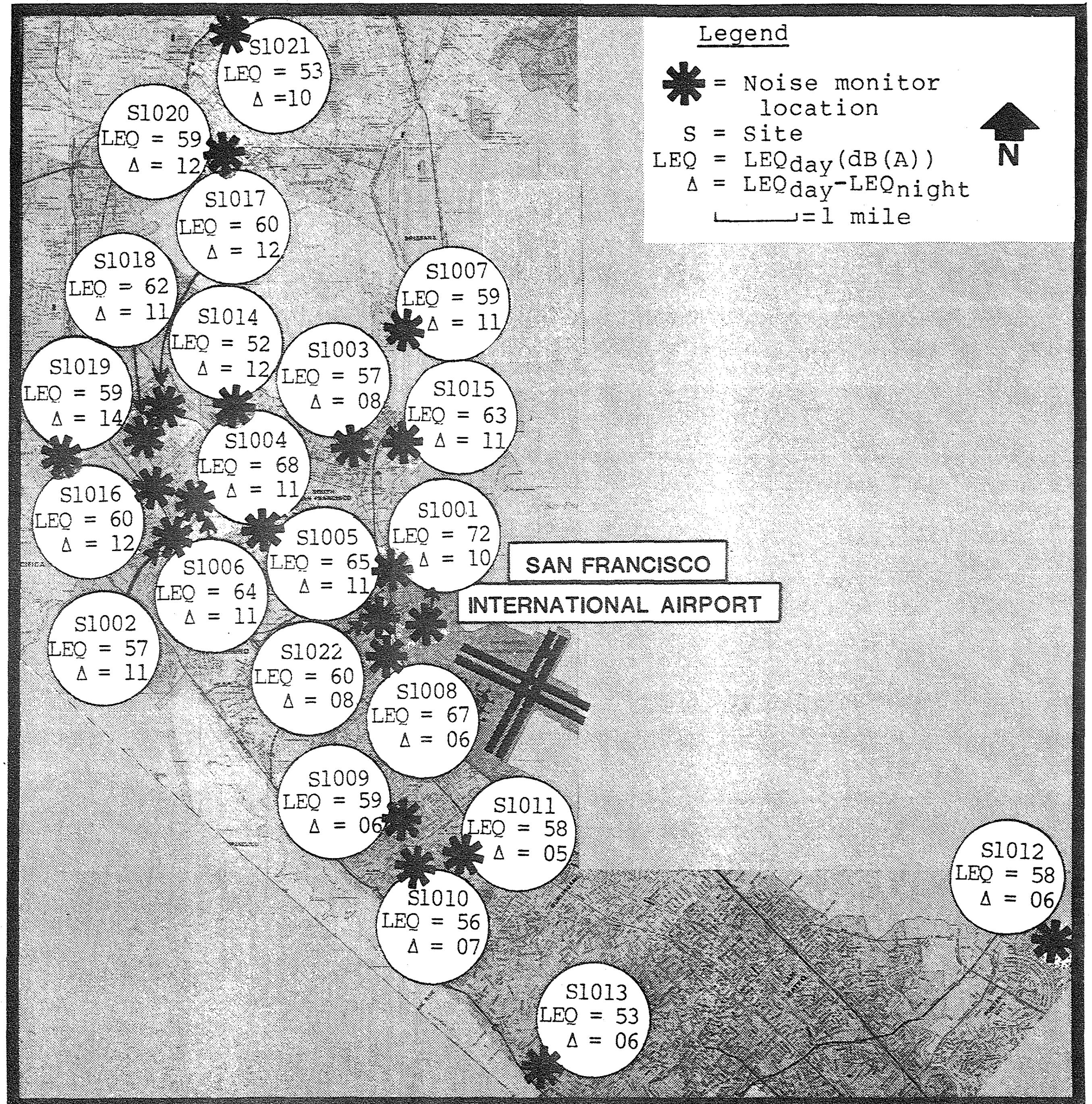

Figure C-10. Permanent noise monitoring sites: San Francisco International Airport (San Francisco, Ca.)

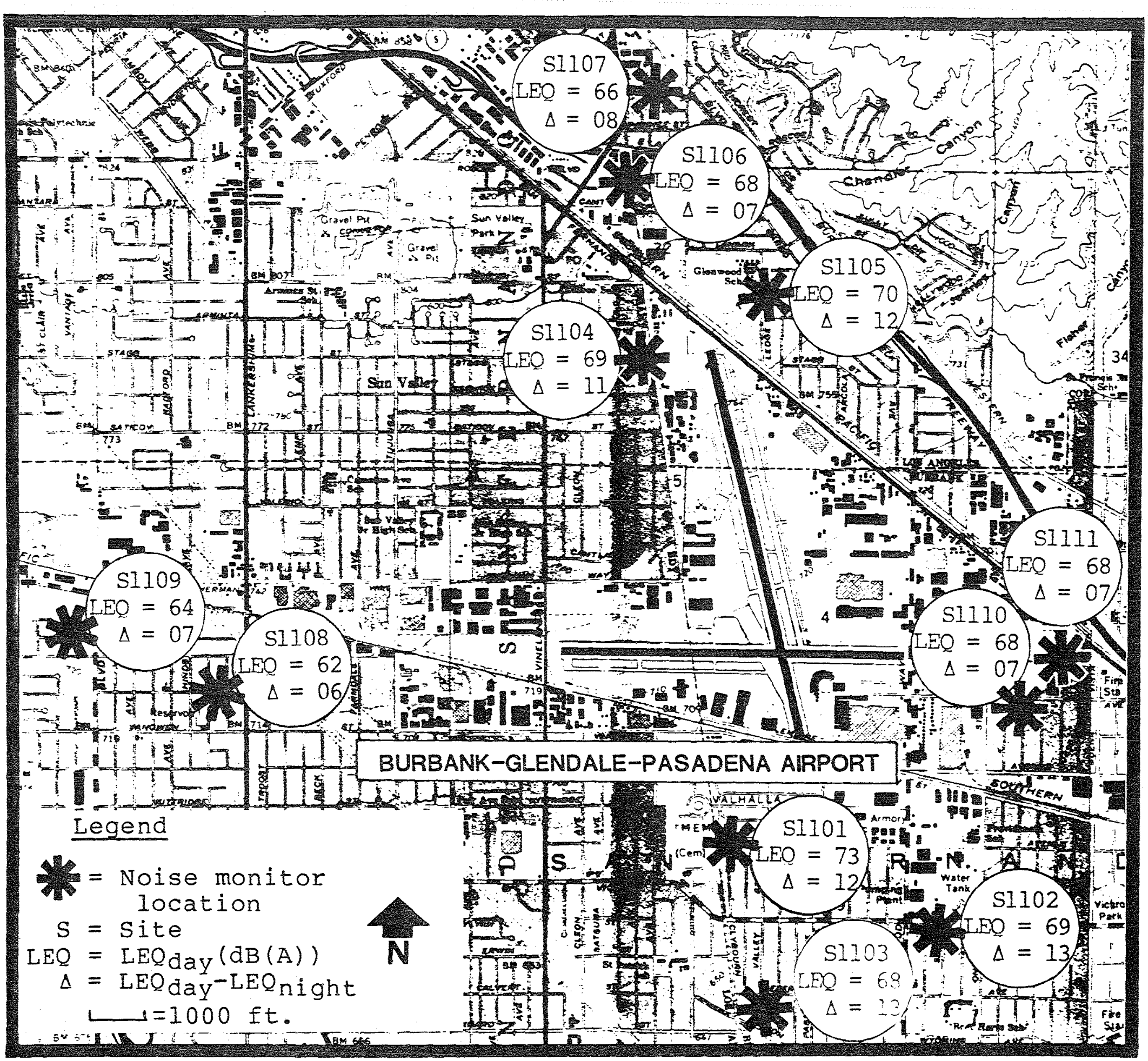

Figure C-11. Permanent noise monitoring sites: Burbank-Glendale-Pasadena Airport (Burbank, Ca.)

APPENDIX D

LOCATION OF NAVY AND MARINE CORPS AIR STATIONS

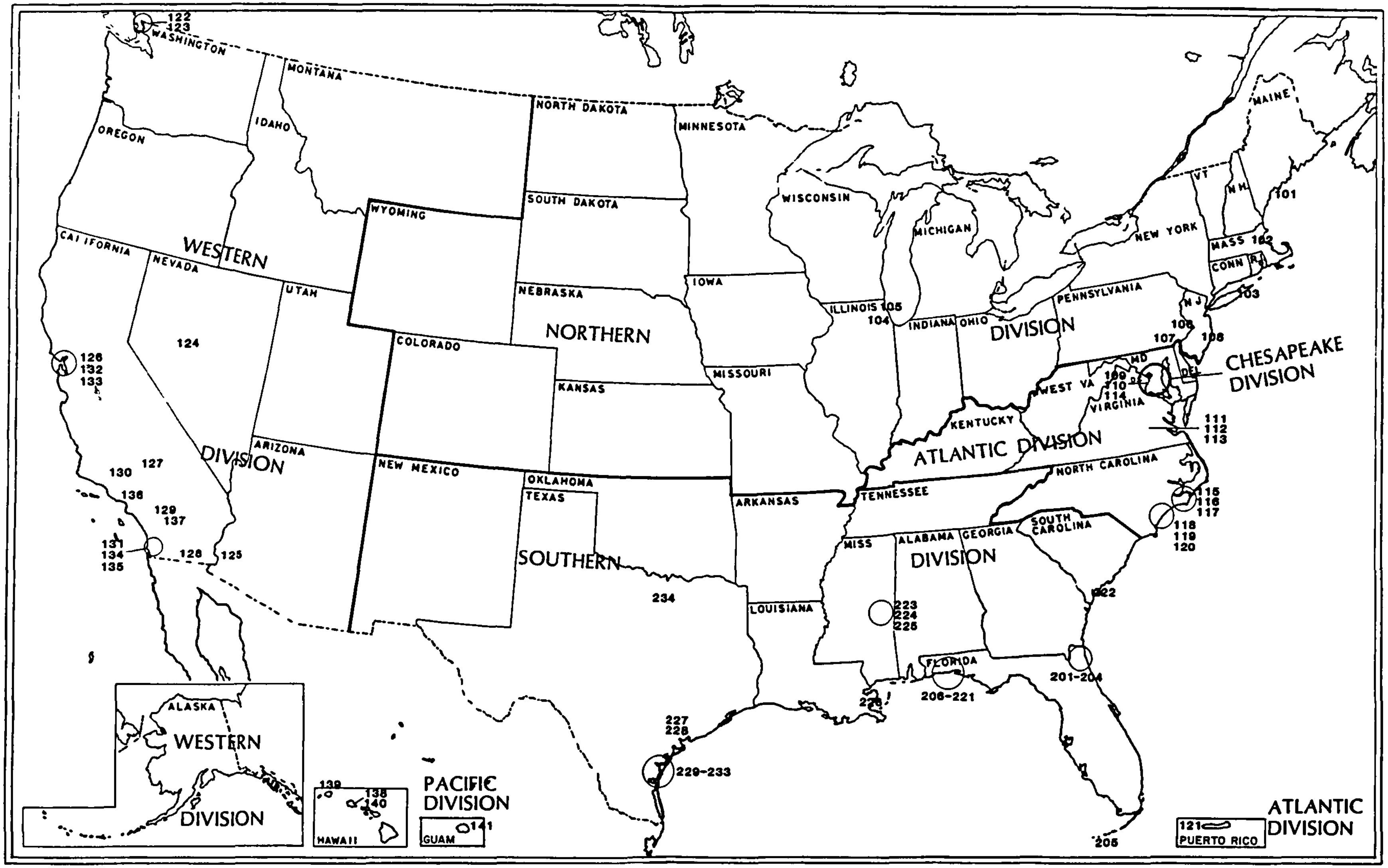

Figure D-1: Location of Navy and Marine Corps Air Stations (Key for identification numbers on next page).

List of identification numbers used in Figure D-1.

101 NAS Brunswick, ME
102 NAS South Weymouth, MA
103 NWIRP Calverton, NY
104 NAS Glenview, IL
105 OLF Libertyville, IL
106 NADC Warminster, PA
107 NAS Willow Grove, PA
108 NAS Lakehurst, NJ
109 NATC Patuxent River, MD
110 NESEA Patuxent River, MD
111 NAS Norfolk, VA
112 NAS Oceana, VA
113 ALF Fentress, VA
114 MCAF Quantico, VA
115 MCAS Cherry Point, NC
116 MCOLF Atlantic, NC
117 MCALF Boque, NC
118 MCAS (H) New River, NC
119 HOLF Camp Davis, NC
120 HOLF Oak Grove, NC
121 NAVSTA Roosevelt Roads, PR
122 NAS Whidbey Island, WA
123 OLF Coupeville, WA
124 NAS Fallon, NV
125 MCAS Yuma, AZ
126 NAS Alameda, CA
127 NAS China Lake, CA
128 NAF El Centro, CA
129 MCAS El Toro, CA
130 NAS Lemoore, CA
131 NAS Miramar, CA
132 NAS Moffett Field, CA
133 NALF Crows Landing, CA
134 NAS North Island, CA
135 OLF Imperial Beach, CA
136 NAS Point Mugu, CA
137 MCAS(H) Santa Ana, CA
138 NAS Barbers Point, HI
139 PMR Barking Sands, HI
140 MCAS Kaneohe Bay, HI
141 NAS Agana, GU

201 NAS Cecil Field, FL
202 OLF Whitehouse, FL
203 NAS Jacksonville, FL
204 NAVSTA Mayport, FL
205 NAS Key West, FL
206 NAS Pensacola, FL
207 OLF Bronson, FL
208 OLF Choctaw, FL
209 OLF Silverhill, AL
210 NAS Whiting Field, FL
211 OLF Brewton, AL
212 OLF Middleton, AL
213 OLF Saufley, FL
214 OLF Spencer, FL
215 OLF Wolf, AL
216 OLF Barin, AL
217 OLF Harold, FL
218 OLF Holley, FL
219 OLF Pace, FL
220 OLF Santa Rosa, FL
221 OLF Summerdale, AL
222 MCAS Beaufort, SC
223 NAS Meridian, MS
224 OLF Alpha, MS
225 OLF Bravo, MS
226 NAS New Orleans, LA
227 NAS Chase Field, TX
228 NALF Goliad, TX
229 NAS Corpus Christi, TX
230 NALF Cabaniss, TX
231 NALF Waldron, TX
232 NAS Kingsville, TX
233 NALF Orange Grove, TX
234 NAS Dallas, TX

APPENDIX E

AICUZ SUMMARY INFORMATION RELATING TO AIRCRAFT NOISE

Standard Form for AICUZ Summary Information
(Key to entries begins on next page.)

AIR STATION					LOCATION	
NAVFAC DIVISION 2		AICUZ DATE 3	FOUO 4		A&E 5	
ACRES 6	EASEMENTS 7		ELEVATION 8		VALUE 9	$ TO ECONOMY 10
APZ TYPE 11	CONTOUR TYPE 12				A95 AGENCY 13	
STATION MISSION					JURISDICTIONS IMPACTED 14	
OBSTRUCTIONS / AIRSPACE 15					TERRAIN. WEATHER ECONOMICS. GROWTH 16	
RUNWAYS / OPERATIONS ORIENTATION UTILIZATION LENGTH 17 TOTAL ANNUAL OPS 18 FW / HELO %'s: 19 DAY / NITE %'s: 20 FCLP's: 21					AIRCRAFT TYPES BASED ITINERANT 22	

Key to Entries on Standard Form for AICUZ Information

1 Each air station has been assigned a three-digit code based upon its location and NAVFAC Division. All Divisions except SOUTHDIV are in the 100 series and are contained in Volume I, while SOUTHDIV Stations are all in the 200 series and in Volume II. The map immediately following the table of contents shows the physical location of all stations.

2 The NAVFAC Division having responsibility for the station AICUZ is shown here.

3 This is the date of final acceptance of the AICUZ report by CNO. The study itself was completed anywhere from 6 months to 1 year prior to this acceptance date.

4 Early AICUZ studies were prepared in two parts, and the implementation recommendations are contained in a volume "For Official Use Only" (FOUO). Later studies are contained in a single volume. A "yes" in this box indicates that there is a separate "FOUO" volume; a "no" indicates a single volume AICUZ report without a classified section.

5 This is the consultanting firm, or NAVFAC Division, that performed the study.

6 Air station acres are shown here. These are fee simple acres and include all property continguous to the airfield itself. Where the air station is a portion of a large installation (e.g., NAS Norfolk, MCAS(H) New River) the acreage shown is that directly under command of the air station staff.

7 Easement acres are those properties outside the station boundaries where avigation easements have been acquired to permit the continual impact of overflying aircraft. Easements for any purposes other than avigational are not included here.

8 Elevation of the airstrip above sea level.

9 Book value in dollars of the air station property and improvements. When the AICUZ study did not include these data, this field is left blank.

10 The dollar value of annual payroll and local services are included (when given) here.

11 Accident Potential Zones (APZ's) are of three categories: Type A for those runways servicing only small, reciprocating engine aircraft; Type B for all larger and jet-engined aircraft; and helicopter APZ's for strictly helicopter pad operations. An "A," "B," or "Helo" are entered here to indicate which size zones apply at this air station.

12 Aircraft Noise Contours in the older AICUZ studies were done in either the NEF or CNR techniques. In 1978 the Navy adopted the Ldn technique, and all AICUZ updates or studies since that time have been done in this methodology. Air stations in California are an exception--State Law there dictates that CNEL be utilized. (CNEL is similar to Ldn, differing only in that an evening time noise penalty is assessed as well as a nighttime penalty.)

13 The disbursement of Federal funds in any area must first be "cleared" by a local jurisdiction (normally an area-wide Council of Governments) to assure that duplicate efforts are not taking place, and that all jurisdictions are aware of, and agree with, the proposed effort. This review process is initiated by the preparation and distribution of an A95 Form. The agency having the responsibility for the A95 Form for the air station's region is identified in this space.

14 The state, county, and city governments being impacted by the air station operations are listed here.

15 Natural terrain obstructions to the clear use of the airfield by aircraft are identified. Movable obstructions, e.g., trees, buildings, antennas, etc., are not included. Airspace availability is also identified. Congested airspace, i.e., the use of airspace by aircraft using other airports and restricting the free and uninhibited use of the airspace by the air station aircraft, is noted where applicable.

16 Brief comments concerning the air station environs, physical and economic, are included here.

17 The airfield runways are identified by directional number, and their length is given. The utilization percentages indicate the direction of operation. These directions are usually dictated by wind and weather conditions, but obstructions and airspace availability sometimes dictate specific operational directions. A typical entry might be: 4/22 80%-20% 8,000. This translates as an 8,000-foot long runway at a heading of 40 degrees with a reciprocal heading of 220 degrees. Aircraft operate in the 40 degree heading 80 percent of the time, and in the 220 degree heading the remaining 20 percent of the time. (All utilizations are on an annual basis.) If more than one runway is involved, the sum of ALL percentages must equal 100 percent.

18 This is the total annual aircraft operations used in the AICUZ study to determine noise contours. An operation is a takeoff or a landing; a touch-and-go training flight, for example, is two operations.

19 Of the total operations, the percentage performed by fixed-wing (FW) aircraft and the percentage by rotary wing (Helo) aircraft are given here. FW percentage is given first.

20 Of the total operations, the percentage performed in the daytime (7:00 a.m. to 7:00 p.m.) and the percentage in the nighttime

(10:00 p.m. to 7:00 a.m.) are indicated here. The daytime percentage is given first. These data are needed for noise contouring because nighttime operations are penalized as being more disruptive.

21 The "Yes" or "No" indicates whether Fleet Carrier Landing Practices (FCLP) or Fleet Mirror Landing Practices (FMLP) flown at the air station.

22 The types of aircraft based at the air station (at the time of the AICUZ study) are listed, along with the most common types of visiting aircraft.

REFERENCES

Bennett, R.L. and Pearson, K.S.: 1981, Handbook of Aircraft Noise Metrics, NASA Contractor Report 3407, March 1981.

Fields, J.M.: 1984, The Effect of Number of Noise Events on People's Reactions to Noise: An Analysis of Existing Survey Data. J. Acoust. Soc. Am., vol. 75, no. 2, pp. 447-467.

Nie, N.H.; Hull, C.H.; Jenkins, J.G.; Steinbrenner, K. and Bent, D.H.: 1975, Statistical Package for the Social Sciences, McGraw Hill, New York.

TABLE I: AIRPORTS WITH HIGH (GREATER THAN 15%) AND LOW (LESS THAN 5%) PERCENTAGES OF NIGHTTIME FLIGHTS (UNITED STATES AIRPORTS WITH AT LEAST 100 FLIGHTS PER WEEKDAY)

Airport	Code	Total No. of daily move-ments	Percentage of flights at three times of day			Difference between night and 15-hr day due to numbers[a] (dB, LEQ)
			Day 0700-1859	Evening 1900-2159	Night 2200-0659	
PART A: HIGH NIGHTTIME USAGE AIRPORTS (GREATER THAN 15%)						
Memphis, Tenn.	MEM	524	65	17	18	6
Kena, Alaska	ENA	120	71	13	16	7
New Haven, Conn.	HUN	144	74	11	15	8
Knoxville, Tenn.	TYS	113	75	10	15	8
Oakland, Col.	OAK	142	70	15	15	8
PART B: LOW NIGHTTIME USAGE AIRPORTS (less than or equal to 5%)						
Louisville, Ky.	SDF	209	84	21	5	13
Nashville, Tenn.	BNA	212	81	14	5	13
La Guardia, N.Y.	LGA	853	78	17	5	13
Minneapolis, Minn.	MSP	667	84	11	5	13
Hyannis, Mass.	HYA	160	82	13	5	13
Boston, Mass.	BOS	932	88	7	5	13
Salt Lake, Utah	SLC	334	80	15	5	13
Nantucket, Mass.	ACK	128	81	14	5	13
Houston, Tx.	IAH	756	82	14	4	14
Kansas City, Ks.	MCI	427	83	13	4	14
San Jose, Cal.	SIC	242	82	14	4	14
Charlotte, N.C.	CLT	584	78	18	4	14
Orlando, Fl.	MCO	399	83	13	4	14
Tampa, Fl.	TPA	651	80	16	4	14
Columbus, Ohio	OMH	253	81	15	4	14
St. Louis, Mo.	STL	918	81	15	4	14
Albany, N.Y.	ALB	201	80	16	4	14
Tallahassee, Fl.	TLH	174	81	16	3	15
Dulles, Va	DCA	774	78	19	3	15
Denver, Co.	DEN	1763	83	14	3	15
Burbank, Ca.	BUR	152	83	16	1	19

a If the peak noise levels and durations of night and daytime flights are the same, then the differences in noise levels (LEQ) are a function of the ratio of the numbers of daytime and nighttime flights:

$$\text{Difference in noise level} = \text{Log}_{10}\ (\text{Percent Day/Percent Night})$$

TABLE II: AIRPORTS WHICH ARE NOT INCLUDED IN THIS STUDY BUT ARE BELIEVED TO HAVE NOISE MONITORING SYSTEMS

Code	Airport, Location	Reason for not including in study
JBR	Jonesboro Municipal, Jonesboro, Ar.	
LIT	Adams Field, Little Rock, Ar.	
OUN	Max Westheimer, Norman, Ok.	
PWA	Wiley Post, Oklahoma City, Ok,	
RHV	Reid-Hillview Field, San Jose, Ca.	Identified as being too small in FAA screening procedure (Many have no scheduled air carrier operations)
SAC	Sacramento Executive, Sacramento, CA.	
FYV	Drake Field, Fayetteville, Ar.	
RAP	Rapid City Reg., Rapid City, S.D.	
BKX	Brookings Municipal, Brookings, S.D.	
SBA	Santa Barbara Municipal, Santa Barbara, Ca.	
SMO	Santa Monica Municipal, Santa Monica, Ca.	
PHX	Phoenix Sky Harbor, Intl., Phoenixm, Az.	No permanent monitoring system (only mobile system)
TUL	Tulsa Intl., Tulsa, Ok.	
SLC	Salt Lake City Intl., Salt Lake City, Utah	
MCI	Kansas City Intl., Kansas City, Mo.	No permanent monitoring system (only mobile system), no population near airport
IAD	Dulles Intl., Chantilly, Va.	No population concentrations near permanent noise monitoring locations
LGB	Long Beach/Daugherty Field, Long Beach, Ca.	Only 2 permanent noise monitoring locations, both on airport property
JFK	John F. Kennedy Intl., New York, NY	
LGA	La Guardia, New York, NY	System only operated to identify events exceeding very high noise level (Exceedence mode)
EWR	Newark Intl., New York, NY	
BOS	Logan Intl., Boston, Ma.	Aircraft information for exceedence mode only, community noise levels include all sources
CLE	Cleveland-Hopkins Intl., Cleveland, Oh.	Only community levels, new system expected in 1985
STL	Lambert-St. Louis Intl., St. Louis, Mo.	System not installed as of May, 1984
HNL	Honolulu Intl., Honolulu, Hi.	Old system down in 1984, new system to be installed

TABLE III: RELATIONS BETWEEN DAYTIME AND NIGHTTIME NOISE LEVELS

Airport	No. of sites	Mean difference (Day-Night) (LEQ)	Std. Dev. of Mean Site Levels			Correlation of day and night LEQ
			Daytime LEQ (15 hr)	Nighttime LEQ (9 hr)	Daytime (15 hr) minus Night (LEQ)	
Wash Natl.	15	11.7	5.3	5.6	2.6	0.89
San Jose	12	11.5	5.6	6.2	2.1	0.94
John Wayne	9	14.4	7.2	5.7	5.9	0.61
Seattle	9	6.1	4.7	5.0	1.2	0.97
Torrence	11	14.1	4.8	7.1	3.4	0.91
San Diego	15	7.6	5.2	5.0	2.7	0.86
Los Angeles	12	5.7	5.4	6.3	1.8	0.96
Ontario	8	11.4	4.2	7.7	6.9	0.45
Van Nuys	4	13.3	1.8	2.8	3.8	0.34
San Francisco	22	9.5	5.0	5.3	2.7	0.86
Burbank	11	9.4	2.9	2.4	2.9	0.44
Mean of all sites[a] (N=128)	11.6	10.1	7.6	9.7	4.2	0.91

a The means and correlations for all sites are computed based on 128 observations (i.e., The observations are not the means of the 11 airport means.)

TABLE IV: COMPARISON OF OAG AND NOISE MONITORING SYSTEM ESTIMATES OF DIFFERENCES IN DAY-TIME AND NIGHT-TIME NOISE LEVELS

Airport	OAG information (Oct 20, 1983		Noise Monitoring Information			Comparison of differences
	% at night	Est. diff. in dB(LEQ)[a]	Year	Mean difference dB(LEQ)	Range of differences over sites dB(LEQ)	OAG minus Monitoring
Wash Natl.	3	15	1981	12	5-15	3
Los Angeles	10	10	1983	6	3-9	4
San Francisco	9	10	1983-84	9	5-14	1
Seattle	12	9	1983-84	6	4-8	3
San Jose	4	14	1982	11	8-16	3
John Wayne	7	11	1983-84	14	3-20	-3
San Diego	9	10	1983	8	3-14	2
Ontario, Ca.	9	10	1983	11	3-17	-1
Burbank	1	20	1983	10	6-15	10

a The difference is estimated on the basis of the numbers of flights during the day and night.

TABLE V: DEFINITION OF NOISE ZONES IN AICUZ STUDIES

Noise description	Noise Zones		
	(Lowest) 1	2	(Highest) 3
LDN	<65	65-75	>75
NEF	<30	30-40	>40
CNR	<100	100-115	>115
CNEL	<65	65-75	>75

1 Report No NASA CR-172612	2 Government Accession No	3 Recipient's Catalog No
4 Title and Subtitle Data on Noise Environments at Different Times of Day Around Airports		5 Report Date June 1985 6 Performing Organization Code
7 Author(s) James M. Fields		8 Performing Organization Report No
9 Performing Organization Name and Address The Bionetics Corporation 20 Research Drive Hampton, VA 23666		10 Work Unit No 11 Contract or Grant No NAS1-16978
12 Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546		13 Type of Report and Period Covered Contractor Report 14 Sponsoring Agency Code 505-35-13-53
15 Supplementary Notes		

16 Abstract

Sources of information about noise environments at different times of day at civilian and military airports are identified. Information about movements of scheduled flights are available in machine readable form from the Official Airline Guide. Information about permanent noise monitoring sites is readily obtained from individual airports. Limited data on the timing of flights are available at centralized locations for military airports.

An examination of scheduled flights at commercial airports leads to the conclusion that differences between daytime and nighttime noise levels (measured in Equivalent Continuous Noise Level, LEQ) vary from 7 to 15 decibels. Data from 128 permanent noise monitoring sites at 11 airports are also examined. Differences between daytime and nighttime noise levels at these 128 noise monitoring sites vary from 3 to 17 decibels (LEQ). Preliminary analyses suggest that accurate estimates of time-of-day weights could not be obtained from conventional social surveys at existing airports.

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