NASA Contractor Report 3490

Community Sensitivity to Changes in Aircraft Noise Exposure

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I. INTRODUCTION

A. Rationale for Current Study

Most quantitative information about community reaction to noise exposure (for example, that summarized by Schultz, 1978) concerns steady state circumstances of both exposure and attitudes. Studies of community reactions to noise exposure usually assume tacitly that the community is thoroughly familiar with prevailing static exposure conditions, and that any transient changes in opinions about exposure have long since turned into a stable, long term set of attitudes. One may wonder if the relationship of annoyance to noise level derived from these conditions is applicable for predicting changes in community response from sudden changes of noise exposure in the community. The current study explores the changes of prevalence of annoyances associated with a series of shifts in aircraft noise exposure in the vicinity of an airport with appreciable air carrier traffic.

The objective of the study was simply to determine if a change in annoyance was associated with a change in noise exposure. Another cause for interest in a study of reaction to changes in exposure is its potential for producing information about the time course and degree of adaptation to noise exposure. Such information could have important implications for regulatory and policy decisions.

Support for the commonsensical observation that people "get used to" noise is mostly anecdotal at present. Adaptation is nonetheless believed to be as an influence on community reaction to noise exposure, as may be inferred from inclusion of a correction factor for "familiarity" or "history of exposure" (EPA, 1979) in the earliest indices of community reaction to noise (cf. Stevens et al., 1955).

Reliable information about community adaptation to changes in noise exposure is sparse not only because research has historically concentrated on other aspects of community reaction to noise exposure, but also because systematic study of the problem poses several procedural problems. Major changes in exposure conditions of the sort likely to produce measurable changes in community reaction rarely arise. Those that do occur are frequently unidirectional and irreversible. Longitudinal experimental designs suitable for collecting the desired sort of information require successive re-interviewing of respondents, careful monitoring of physical exposure conditions, and other potentially costly measures.

The current study took advantage of an unusual set of exposure conditions associated with runway repairs at a major airport. People in one neighborhood in which the noise environment had been dominated by local street traffic were abruptly exposed to an increase in aircraft noise exposure. Several months later, these same people were exposed to a sudden decrease in aircraft noise exposure. At the same time, people in two other neighborhoods long exposed to aircraft noise experienced the complementary pattern of changes in noise exposure. Residents of a fourth nearby neighborhood, which underwent smaller changes in noise exposure through the study period, were available for interviewing for purposes of experimental control. The general pattern of changes in exposure was a matter of public record in advance of the changes.

Thus, it was possible to use consistent survey techniques and repeated acoustic measurements: 1) to determine whether or not a change in prevalence of annoyance is associated with a change in aircraft noise exposure, and 2) to assess the time course of adaptation to changing aircraft noise exposure, and 3) to compare annoyance due to aircraft at Burbank Airport with similar information collected elsewhere.

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B. Anticipated Changes in Exposure and Annoyance

The three panels of Figure 1 suggest relationships between
noise exposure and annoyance at Burbank Airport that might
reasonably have been anticipated on the basis of general know-
ledge of human response to noise exposure*. The topmost plot
shows a pattern of change in community noise exposure
on axes of Day Night Level (L_{dn}) vs. time. Since aircraft
activity and runway utilization at Burbank Airport are fairly
stable from day to day, no large exposure fluctuations were
expected. The step change in exposure occurred when aircraft
traffic patterns changed suddenly as a result of the closure
of the main runway.

Following the step change in exposure, people's attitudes toward
aircraft noise could reasonably have been expected to change
as suggested in the two lower panels of Figure 1. Annoyance
with aircraft noise over the past week was expected to increase
dramatically, with perhaps some overshoot due to overreaction
to exposure change per se. It was expected, however, that
short term annoyance would eventually stabilize at a new
level predictable from the relationship derived by Schultz
(1978) from a number of attitudinal surveys conducted world-
wide.

In contrast, long term annoyance with aircraft noise (repre-
sented in the bottom panel in Figure 1) was expected to increase
in a more gradual manner to a new higher level of annoyance,

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*The expected relationship for decreases in annoyance follow-
 ing decreases in exposure are simply the converse of those
 discussed here.
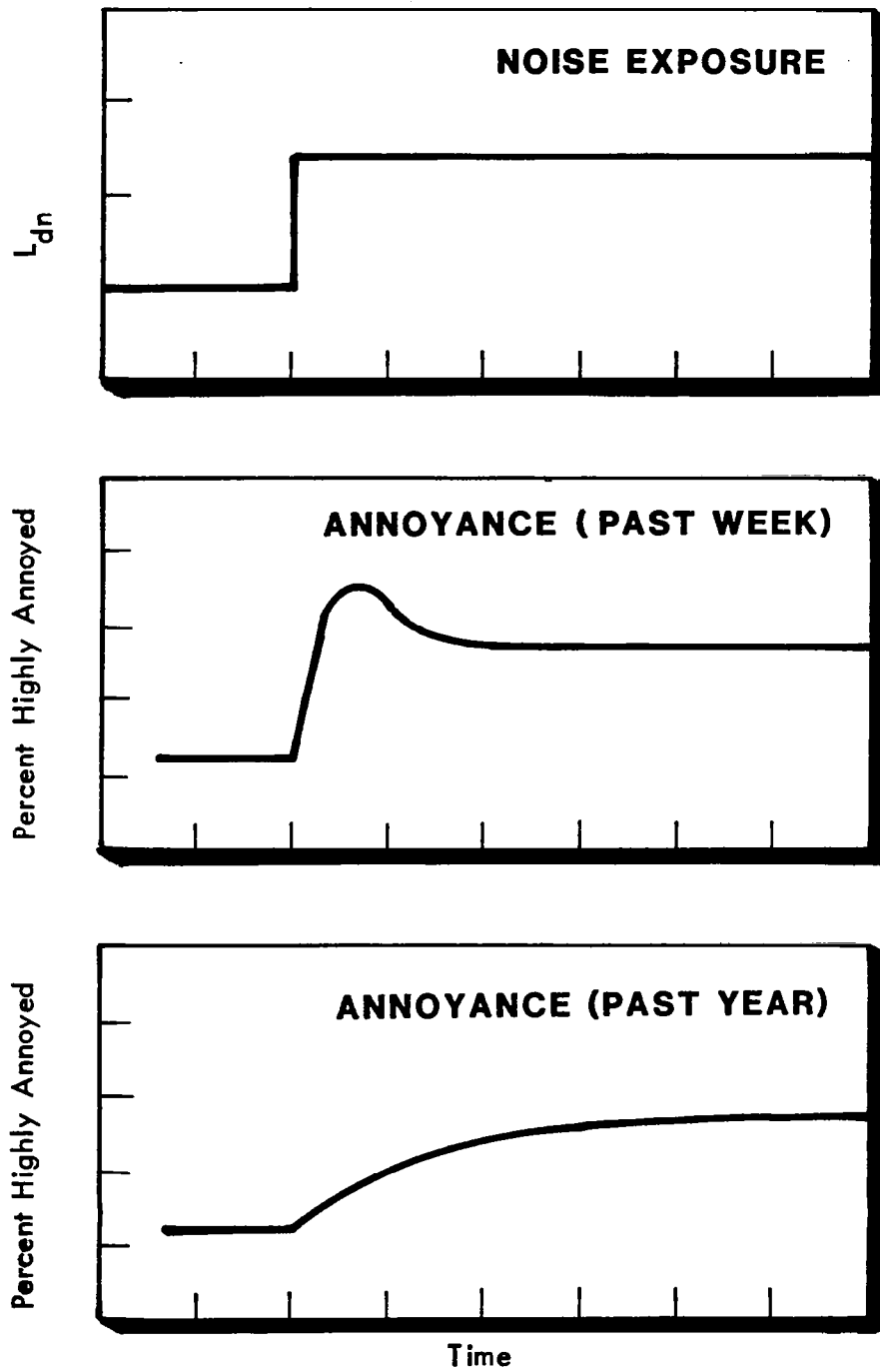
FIGURE 1.   EXPECTED HISTORY OF DOSAGE AND RESPONSE.

with an exponential rate of increase. Short term and long term annoyance were expected to be close to identical before any exposure change, and ultimately to become asymptotic at the same level of annoyance after a long period of time following the step change.

The slopes of the functions relating the rise (and fall) of annoyance to increasing (and decreasing) exposure would not necessarily be identical. Common sense would suggest that annoyance would rise more rapidly following an increase in exposure than it would fall following a decrease in exposure.

C. Acknowledgments

II. METHOD

A. Study Design

A social survey was designed to take advantage of changes in noise exposure associated with runway repairs at Burbank Airport (BUR). In mid-September 1979, most of the main runway (15-33) was closed for repairs. Prior to the closure, Runway 15 supported virtually all scheduled air carrier departures (about 50 per day), half the arrivals (about 25 per day), and about 75% of the general aviation operations (about 450 out of approximately 600 combined arrivals and departures per day) at BUR. The remaining half of air carrier arrivals and the remaining 25% of general aviation operations used Runway 07. At the onset of repairs, all commercial and much general aviation air traffic at BUR was diverted to the cross runway (see Figure 2). The main runway was subsequently closed to all traffic until late December of 1979 (see Figure 3). Repairs to the cross runway began several months later, and were completed by late October, 1980.

Four rounds of interviewing were conducted in conjunction with the changes in noise exposure caused by repairs to the main runway: one immediately before the initial closure of the main runway, and three others before its reopening. A fifth round of interviews was conducted approximately three months after completion of all runway repairs (see Figure 4).

B. Site Selection and Exposure Patterns

Four residential neighborhoods were identified in which aircraft noise exposure was expected to be homogeneous (plus or minus 3 decibels) from extensive prior measurements. Each

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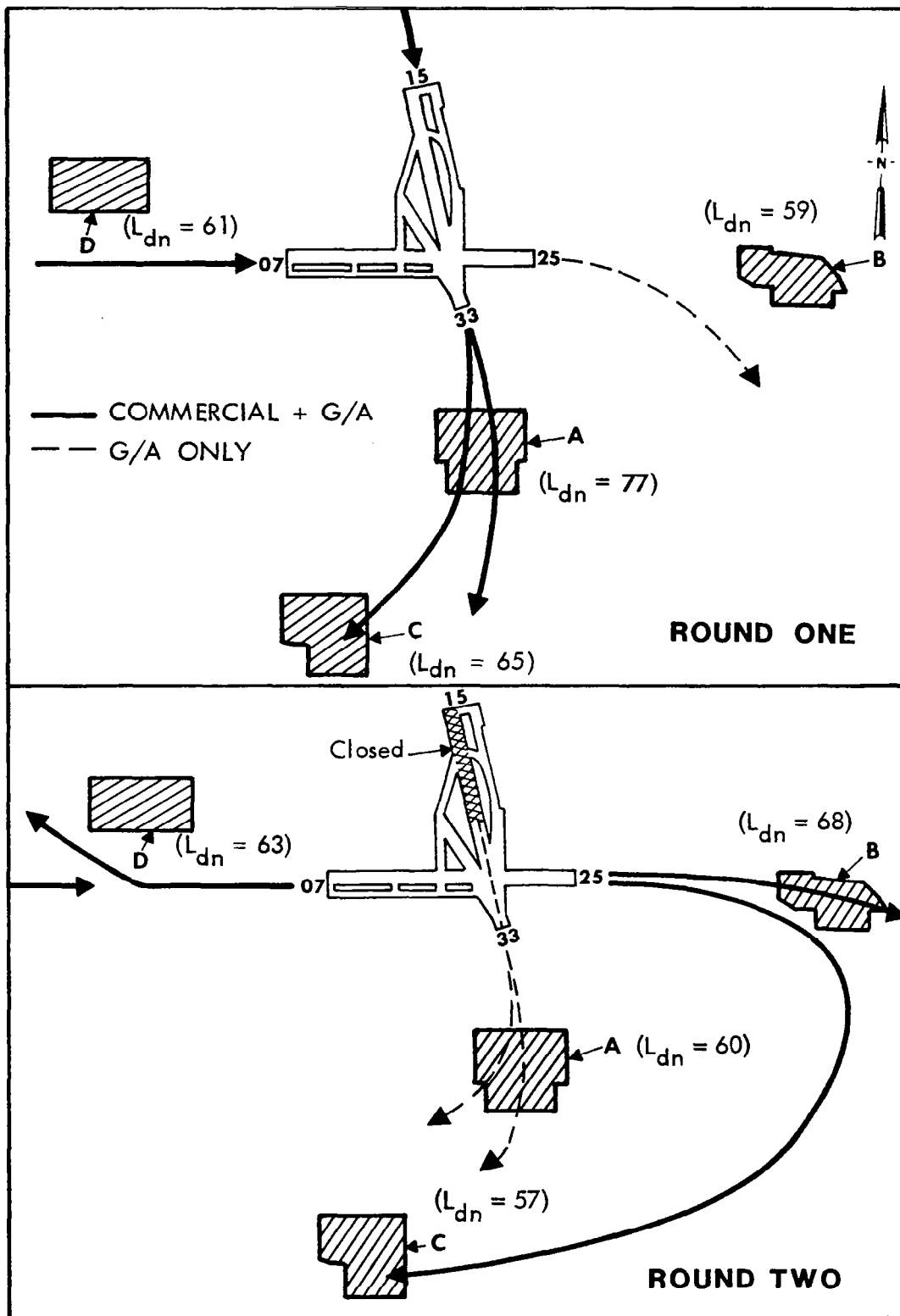
FIGURE 2.   MAP OF INTERVIEWING SITES SHOWING
            PRINCIPAL FLIGHT PATHS - ROUNDS ONE
            AND TWO.
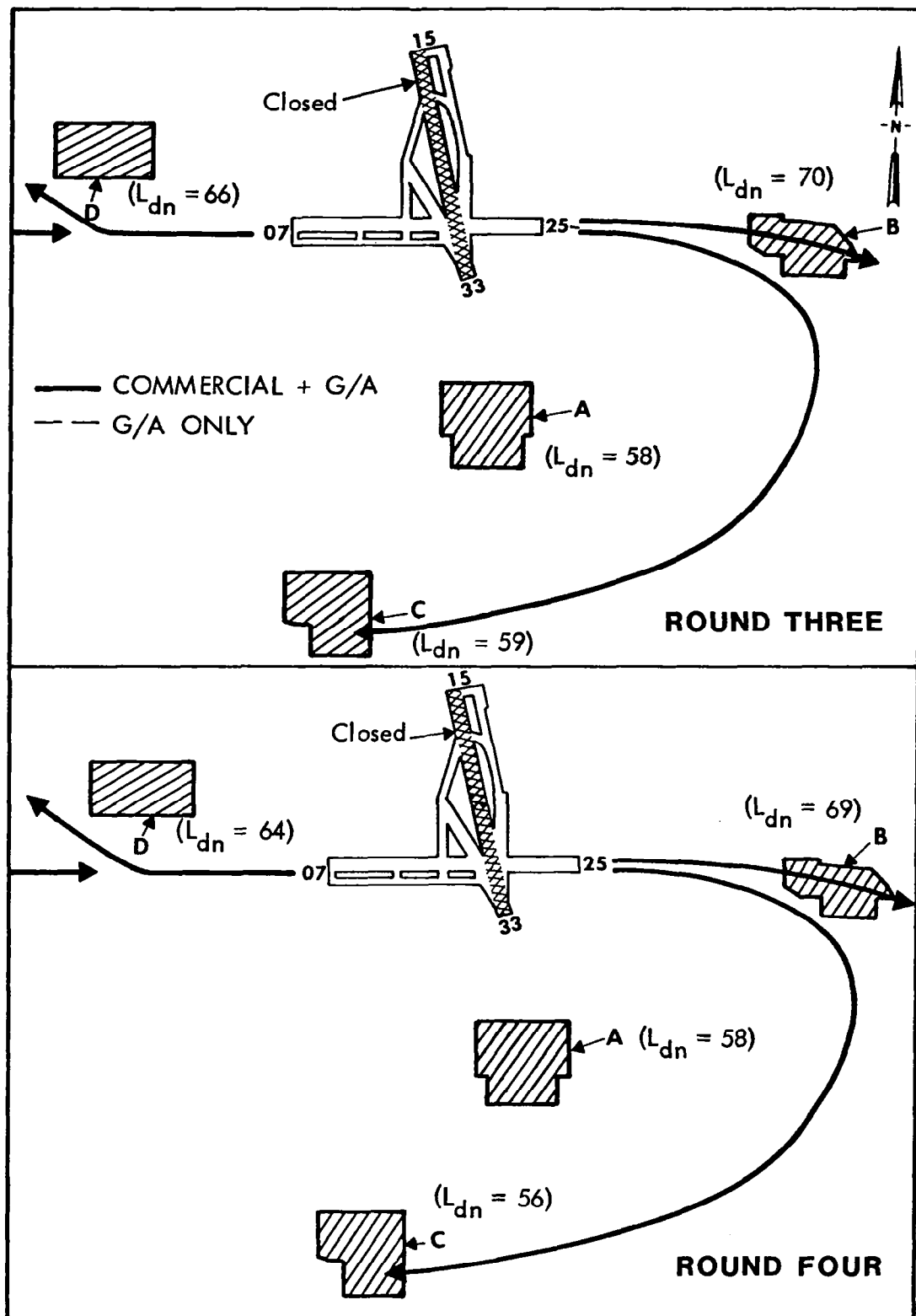
FIGURE 3. MAP OF INTERVIEWING SITES SHOWING
PRINCIPAL FLIGHT PATHS - ROUNDS THREE
AND FOUR.
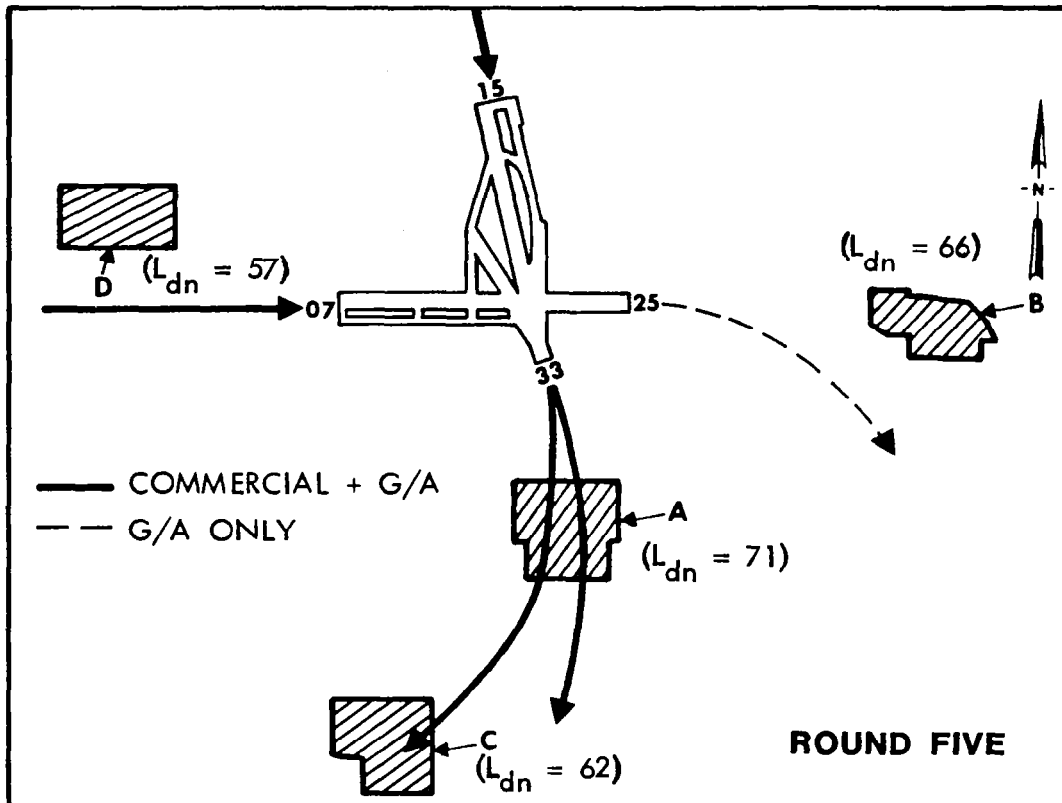
FIGURE 4. MAP OF INTERVIEWING SITES SHOWING
PRINCIPAL FLIGHT PATHS - ROUND 5.

neighborhood contained approximately 200 households. Block
by block decisions about the boundaries of each site were
made on the basis of existing and projected noise exposure
contours. Visits to the sites confirmed that they were
unaffected by highway and other high level noise sources.

Residences in the four neighborhoods were primarily detached
single family, one story wood frame buildings on a regular
grid of two lane streets, with about twenty houses per block
face. A few two story apartment buildings were present at
some of the sites. For many years prior to closure of Runway
15-33, and also upon completion of all runway repairs, Neigh-
borhood A was exposed to about 50 air transport departures
daily at maximum A-levels averaging 105 dB, and to several
hundred general aviation departures at maximum A-levels of
about 85 dB. From mid-September 1979 to early October, 1979,
Neighborhood A was relieved of all air transport overflights
and subjected to smaller than customary numbers of daily
general aviation departures. In early October, 1979, Neigh-
borhood A was also relieved of all general aviation departures
when Runway 15-33 was entirely closed for repairs. Neighborhood
A was subjected to a modest number of general aviation aircraft
in the downwind leg of a right hand traffic pattern on Runway
07.

Neighborhood B, under the departure path of Runway 07, ex-
perienced the complementary change in exposure. Prior to the
closure of the main North-South Runway, Neighborhood B's
noise exposure had been dominated by street traffic noise.
Very few air transport operations overflew the neighborhood,
and sideline noise from such operations was barely audible.
From mid-September to mid-January, 1980, noise exposure in

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Neighborhood B was dominated by aircraft noise, with average single event noise levels higher than those created by street traffic noise.

Neighborhood C, in the flight path of departures from Runway 07 but some distance from the airport, had for years prior to the runway closure been exposed to the same daily numbers of departures as Neighborhood A, but at lower levels. Maximum A-levels from jet aircraft departures in Neighborhood C prior to runway closure averaged 89 dB. Following the closure of the main runway, aircraft departing to the east on the cross runway made a sweeping right turn after takeoff to overfly Neighborhood C, but at a greater altitude than before the change in runways. General aviation operations were well dispersed before reaching this neighborhood.

Noise exposure in Neighborhood D prior to closure of the main runway at BUR was influenced by both aircraft overflights and local street traffic noise. Closure of Runway 15 doubled the number of landings on Runway 07 and increased the number of westerly departures on Runway 25. Maximum A-levels in this neighborhood averaged about 78 dB for approaches and 89 dB for departures.

C. Measurements of Noise Exposure

Neighborhood noise levels were measured during the week preceding each round of interviews by a portable noise monitor installed in the rear yard of a single-story, one family residence centrally located within each neighborhood. These measurements were the basis for estimating noise exposure for individual neighborhoods in all rounds of interviewing.

Sites were selected on the basis of two major criteria:
(1) absence of unusual acoustic barriers, and (2) freedom
from unusual or high level sound sources in proximity to
the microphone. The microphone was mounted on a tripod
approximately 2.4 meters above ground level. Monitor
units were calibrated every other day, but otherwise
operated unattended. Details of the noise monitoring
process may be found in Appendix A. For procedural reasons,
other measurements (as described in Appendix E) were also
made.

D. Sampling

Since the four sites each contained only a few hundred house-
holds, attempts were made to exhaust rather than sample the
adult, English speaking population with one face to face
contact and four telephone callbacks during each round of
interviewing. The sampling frame for each interviewer was
a detailed street map showing block faces along which an
interview was to be attempted at every residence.

As the identical procedure was followed in each round of
interviewing, the resulting sample was tantamount to a panel
sample, although respondents' names were not recorded. Names
were not solicited to guarantee anonymity, thereby improving
the likelihood of multiple re-interviews.

E. Survey Instrument

Since it was anticipated that respondents might become
increasingly unwilling to complete a long interview on
successive rounds of interview, an extremely brief and
direct questionnaire was developed. The first four questions
seen in Figure 5 were asked during the first four rounds of
interviews. The response scale for gauging intensity of

ITEM	QUESTION	RESPONSE	CODE	CARD COL
1	What would you say is the major environmental problem in this (your) neighborhood at this time of year? VERBATIM:_____	Aircraft............... 1 Air Quality............ 2 Other.................. 3 Don't Know............. 6 Not Ascertained....... 7 Refused............... 8		23
2	While you've been at home over the past WEEK (just since last _____), would you say you've been not at all annoyed by street traffic noise, slightly annoyed by street traffic noise, moderately annoyed by street traffic noise, very annoyed by street traffic noise, or extremely annoyed by street traffic noise?	Not At All Annoyed.... 1 Slightly Annoyed...... 2 Moderately Annoyed.... 3 Very Annoyed.......... 4 Extremely Annoyed..... 5 Don't Know............ 6 Not Ascertained....... 7 Refused............... 8		24
3	While you've been at home over the past WEEK (just since last _____), would you say you've been not at all annoyed by aircraft noise, slightly annoyed by aircraft noise, moderately annoyed by aircraft noise, very annoyed by aircraft noise, or extremely annoyed by aircraft noise?	Not At All Annoyed.... 1 Slightly Annoyed...... 2 Moderately Annoyed.... 3 Very Annoyed.......... 4 Extremely Annoyed..... 5 Don't Know............ 6 Not Ascertained....... 7 Refused............... 8		25
4	While you've been at home over the past YEAR (since this time last year), would you say that you've been not at all annoyed by aircraft noise, slightly annoyed by aircraft noise, moderately annoyed by aircraft noise, very annoyed by aircraft noise, or extremely annoyed by aircraft noise?	Not At All Annoyed.... 1 Slightly Annoyed...... 2 Moderately Annoyed.... 3 Very Annoyed.......... 4 Extremely Annoyed..... 5 Don't Know............ 6 Not Ascertained....... 7 Refused............... 8		26
5	Some people think noise from some airplanes using Burbank Airport is more annoying than noise from others. Just on the basis of noise, how many small airplanes flying near your house would it take to annoy you as much as a single large jet?	Small Airplanes More Annoying..............000 Number of Small Airplanes=1 Large Jet...._//_ Don't Know.............666 Not Ascertained........777 Refused................888 VERBATIM:_____		27-29
6	How concerned would you say the people who run the airport and the airplanes are about the feelings and comfort of people who live in this (your) neighborhood?	Not At All Concerned.. 1 Slightly Concerned.... 2 Moderately Concerned.. 3 Very Concerned........ 4 Extremely Concerned... 5 Don't Know............ 6 Not Ascertained....... 7 Refused............... 8		30

FIGURE 5. QUESTIONNAIRE ITEMS.

annoyance was the same closed category scale used in prior studies of annoyance associated with aircraft and other community noise sources (cf. Fidell and Jones, 1973; Fidell, 1978).

Question 1 was intended to direct respondents' attention to environmental matters; to elicit spontaneous mention of aircraft noise as a major environmental problem of local concern; and to place concern with aircraft noise into perspective with the other major environmental problem in the area (air pollution).

Question 2 was intended to further focus the respondents' attention on noise exposure, and on the time frame of the preceding week. It was also intended to provide perspective on the relative degree of annoyance associated with aircraft and street traffic noise exposure.

Question 3 dealt with the issue of greatest interest - opinions about the immediate effects of shifts in noise exposure. Question 4 was intended to aid interpretation of response to Question 3, and to determine how respondents' opinions about long term exposure were affected by recurring changes in exposure.

In the fifth and final round of interviews, the two final questions seen in Figure 5 were asked as well. Question 5 was included in an effort to determine whether the observed prevalence of annoyance in the first four rounds could be attributed in part to the use of the airport by both general aviation and scheduled air carrier aircraft. Question 6 was included to explore another potential non-acoustic source of annoyance in the airport area.

F. Interviewing

About twenty interviewers were trained to administer the
questionnaire both personally (face to face) and by telephone
for each round of questioning. The initial interview attempt
in each round was always in person. Crews of eight or more
interviewers were assigned to canvass specific block faces
within each site, as an initial attempt to obtain an inter-
view with at least one adult per household. Subsequent
callbacks to potential respondents who were not at home
during the daylight personal interviewing hours were made
by telephone at different times of day.

All personal contacts within a site were completed within
half a day. Almost all telephone callbacks were completed
within the next 48 hours. The first four rounds of inter-
views started with personal interviews during daylight hours
on 30 August, 28 September, 10 November, and 8 December, 1979.
The first round preceded runway closure by 18 days. The
second, third, and fourth rounds followed runway closure by
11, 54, and 82 days. The final round of interviews started
in the same manner on 20 December, 1980, two months after
completion of repairs to the cross runway.

III. RESULTS

Analyses of findings of the physical and social measurements
are presented in the following order in this section. Measured
noise exposure levels are summarized first, after which responses
to the six substantive questionnaire items are analyzed. Appendix
B contains information about the mechanics of interviewing and raw dat:

A. Noise Exposure Information

1. Differences Among Neighborhoods

Table 1 summarizes the observed L_{dn} values for both aircraft
noise and ambient noise at each site in the week preceding
each round of interviews. The patterns of changes in aircraft
noise exposure in the four interviewing areas were generally
as expected. In Neighborhoods A and C, levels were appreciably
lower following the closure of the main runway than they had
been for several years. Aircraft noise exposure levels increased
considerably in Neighborhood B, but only slightly in Neighborhood
D.

The pattern of aircraft noise exposure levels observed in
the four neighborhoods in the week preceding the fifth round
of interviews resembled the pattern observed in the week pre-
ceding the first round of interviews in general, but not in
detail. Aircraft noise exposure in three of the four neighbor-
hoods (A, C and D) was less intense in December 1980 than in
August 1979 by three to six decibels, due primarily to reduced
flight frequencies by commercial air carriers. Aircraft noise
exposure in December 1980 was seven decibels higher in Neigh-
borhood B than it had been in August 1979, due to increased
use of the resurfaced cross runway.

TABLE I. DAY-NIGHT NOISE LEVELS OF AIRCRAFT AND AMBIENT
EXPOSURE AT THE INTERVIEWING SITES, IN dB

	Aircraft Noise Exposure				
Neighborhood	Round 1	Round 2	Round 3	Round 4	Round 5
A	77	60	58	58	71
B	59	68	70	69	66
C	65	57	59	56	62
D	61	63	66	64	57

	Ambient Noise Exposure			
Neighborhood	Round 1	Round 2	Round 3	Round 4
A	--	50	49	--
B	56	57	60	56
C	--	50	51	53
D	56	51	52	52

2. Variability of Levels Within Neighborhoods

Figure 6 shows the NOISEMAP-generated L_{dn} contours at 1 decibel intervals superimposed on each interview neighborhood and vicinity. The heavy broken line shows the interview neighborhood boundary, while the circled star within the boundary line indicates the position of the central noise monitoring site.

The L_{dn} contours, intended to illustrate gradients only, were generated from detailed 1980 typical day information (without runway closures) concerning aircraft flight paths, flight path utilization, aircraft mix, and noise and performance information for these aircraft. Since interviewing areas were selected in part on the basis of their exposure to a single runway's operations, day-to-day and round-to-round variations in runway utilization could be expected to affect the absolute magnitude of the contour values, but would be unlikely to affect the exposure gradient appreciably. To minimize confusion, arbitrary absolute values have been assigned to the contours shown in the figures. Based on these contours, the exposure extremes across the interview neighborhoods (re the central monitoring site) are estimated as follows for Rounds 1 and 5:

Neighborhood	Deviation from Central Monitoring Point
A	+2, -2½ dB
B	+2½, -3
C	+1, -1½
D	+2, -5

For Rounds 2-4 the shift in operations would change the shape of the contours in Figure 6. However the deviations in level from the central monitoring point should be no greater than those listed above for Rounds 1 and 5.
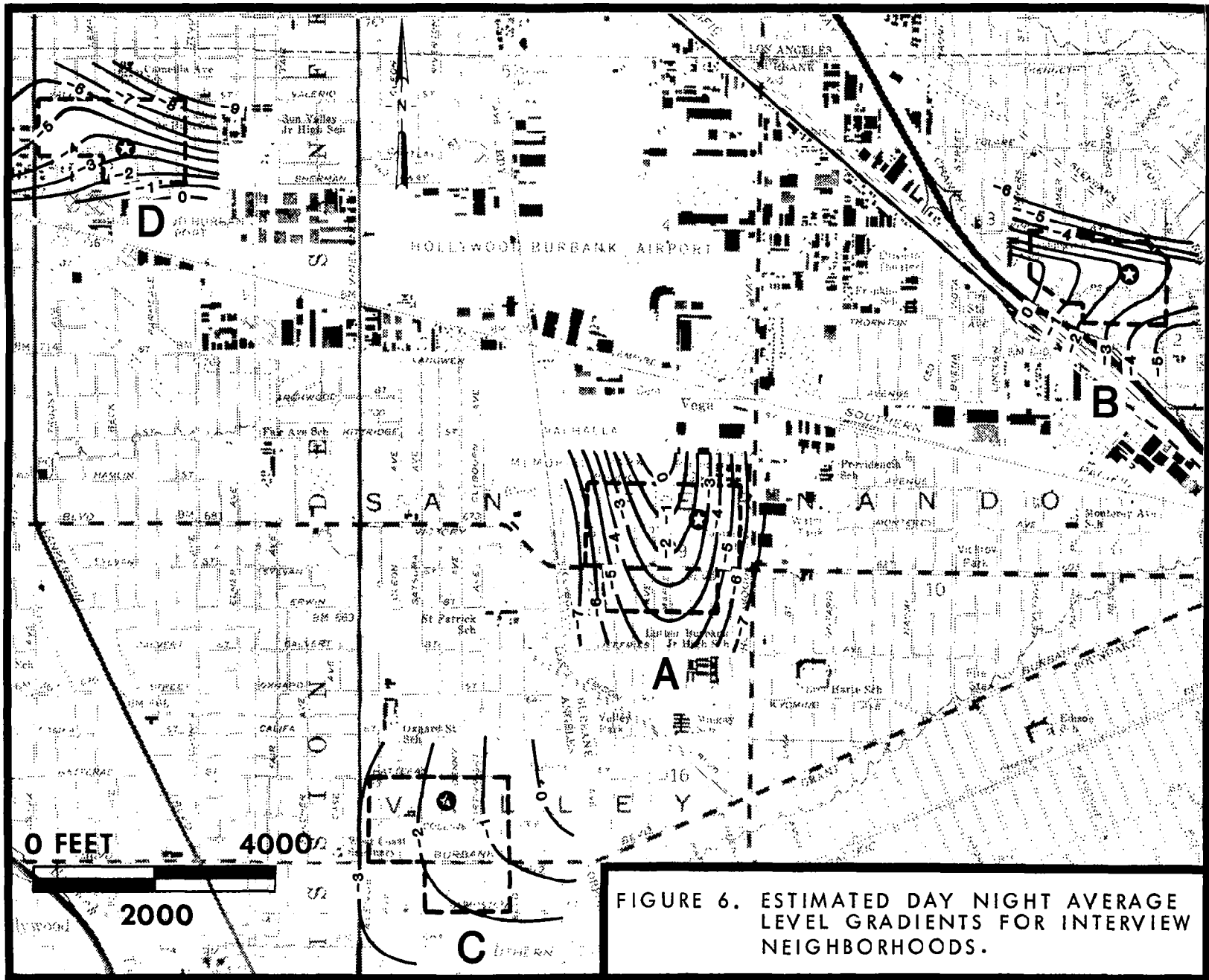
FIGURE 6. ESTIMATED DAY NIGHT AVERAGE LEVEL GRADIENTS FOR INTERVIEW NEIGHBORHOODS.

B. Attitudinal Information

1. Analysis of Responses to Question 1

Question 1 elicited the respondent's opinion of the major
environmental problem in his neighborhood. Responses were
recorded as spontaneous mentions of aircraft, air quality
or any other environmental concern.

Figure 7 summarizes the changes observed in proportions of
respondents at each site who spontaneously cited aircraft
noise as the major environmental problem at the current time
of year. For purposes of comparison, aircraft noise exposure
during the week preceding each round of interviews is also
plotted on the same figure.

The trend in proportions of respondents citing aircraft noise
as the major environmental problem reflected actual noise
exposure. In fact the patterns throughout the four rounds
of interviewing of aircraft noise exposure and proportions
identifying aircraft noise as the major neighborhood environ-
mental problem are similar for all neighborhoods as shown
in Figure 7.

2. Analyses of Responses to Question 2

a. Dosage Response Relationships

Proportions of respondents annoyed by traffic noise in
the preceding week are quite consistent and do not
differ significantly within neighborhoods from round
to round. In all cases, however, the percentage of res-
pondents highly annoyed exceeds the percentage predicted
by Schultz (1978) by about 7% on average. Figure 8 plots the
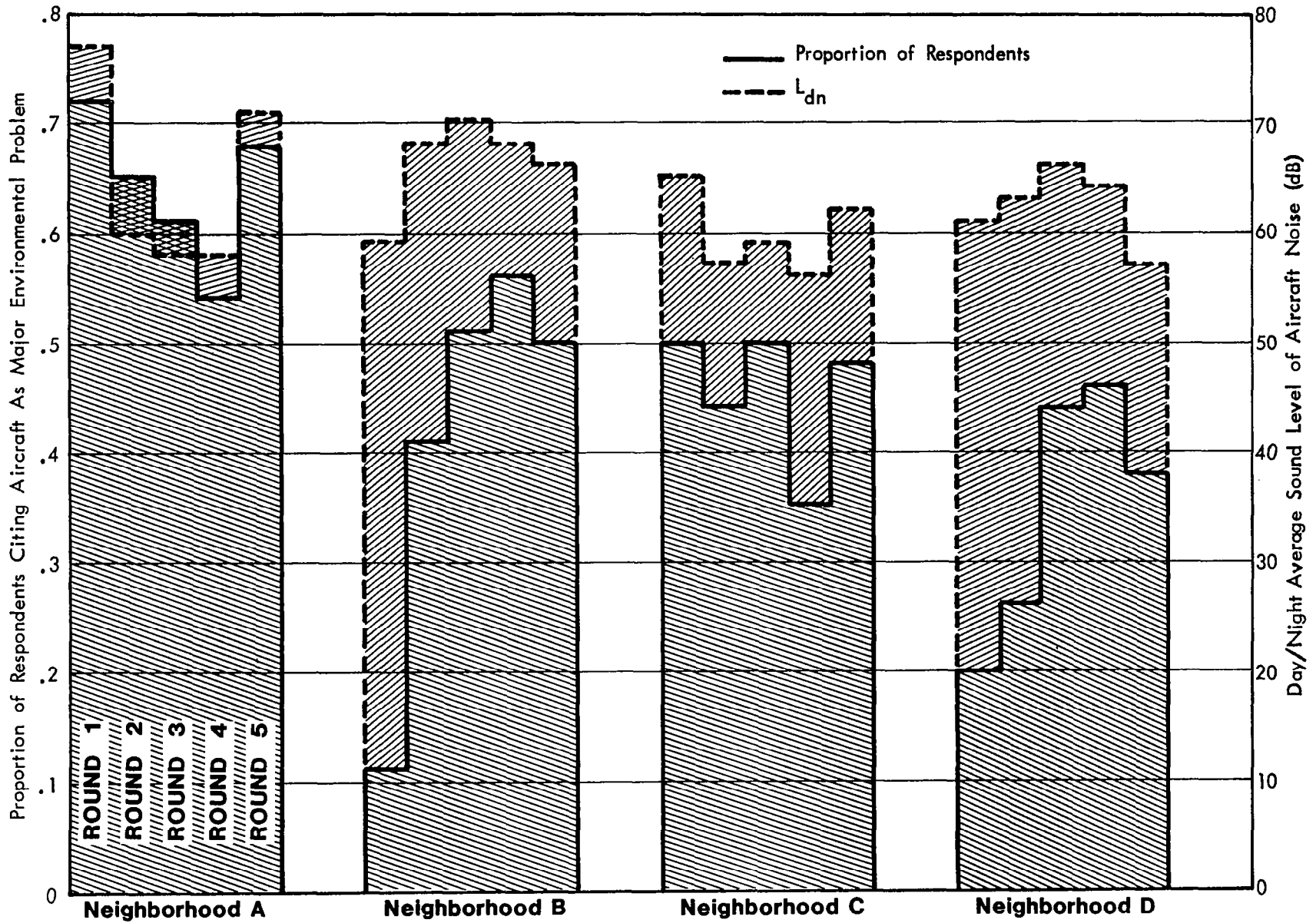
FIGURE 7.   AIRCRAFT NOISE EXPOSURE AND PROPORTIONS OF RESPONDENTS CITING
AIRCRAFT NOISE AS THE MAJOR NEIGHBORHOOD ENVIRONMENTAL PROBLEM
AT THIS TIME OF YEAR FOR EACH ROUND OF INTERVIEWS.
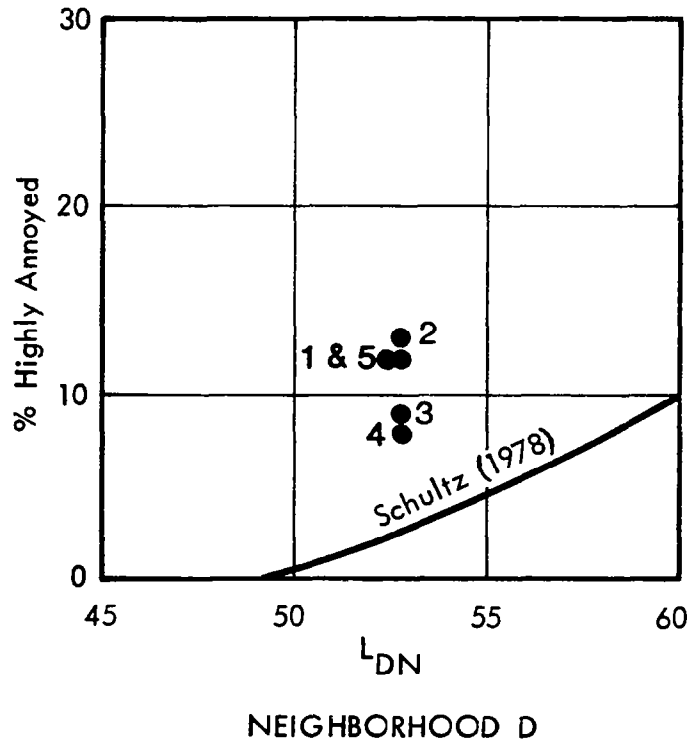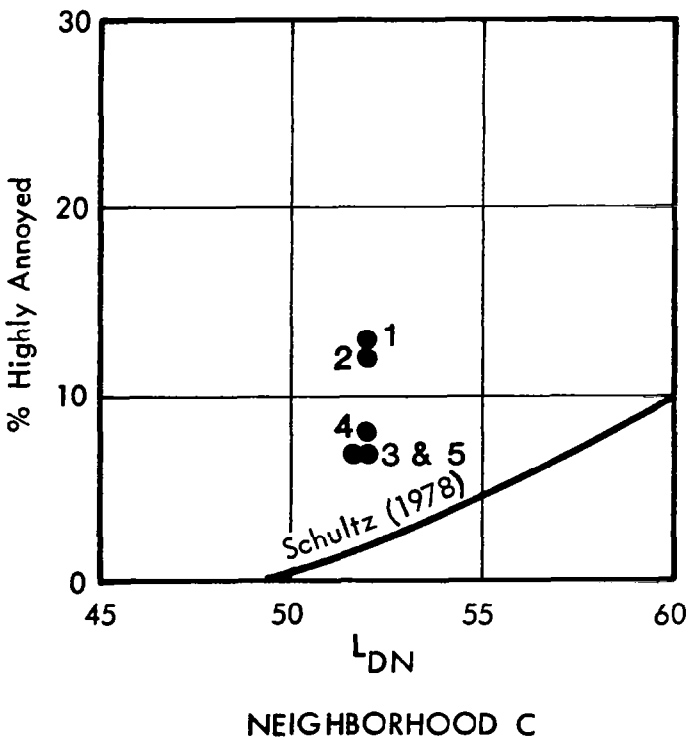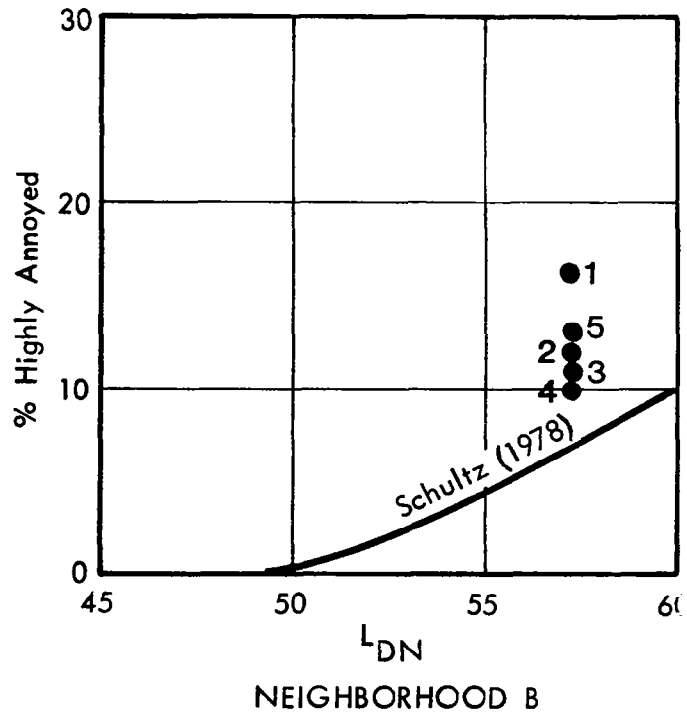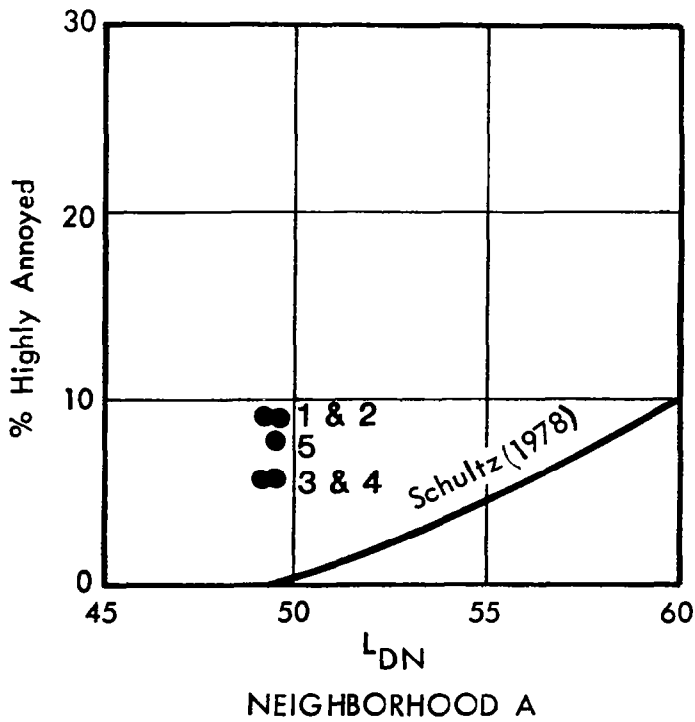
FIGURE 8. ANNOYANCE DUE TO STREET TRAFFIC NOISE OVER THE PAST WEEK FOR FIVE ROUNDS OF INTERVIEWING.

percentage of respondents highly annoyed during each round
of interviewing against the mean ambient noise level measured
in each neighborhood. The figure also shows the relationship
of these data to the relationship of Schultz (1978). Further
analysis of the variability of annoyance to traffic noise is
provided in Appendix C.

3. Analyses of Responses to Question 3

a. Effects of Exposure History on
Immediate Annoyance

The top two panels of Figure 9 show the effects of changes
in aircraft noise exposure on immediate annoyance. Note that
exposure changes resembled those anticipated in Figure 1.
Note also that the changes in annoyance reflected the
observed changes in exposure (see Table I).

b. Relationship of Current Findings About Immediate
Annoyance of Aircraft Noise to Prior Findings

The prevalence of annoyance due to aircraft noise in the
week preceding interviewing is consistent with changes in
exposure within neighborhoods, but is in poor agreement with
a well known dosage-response relationship (Schultz 1978), as
illustrated in Figure 10. Also shown in Figure 10 is the least
squares regression line, bounded by its 95% confidence limits.

4. Analyses of Responses to Question 4

a. Effects of Exposure Change on Long Term Annoyance

The bottom panel of Figure 9 shows the effects of the step
changes in exposure on long term attitudes toward aircraft
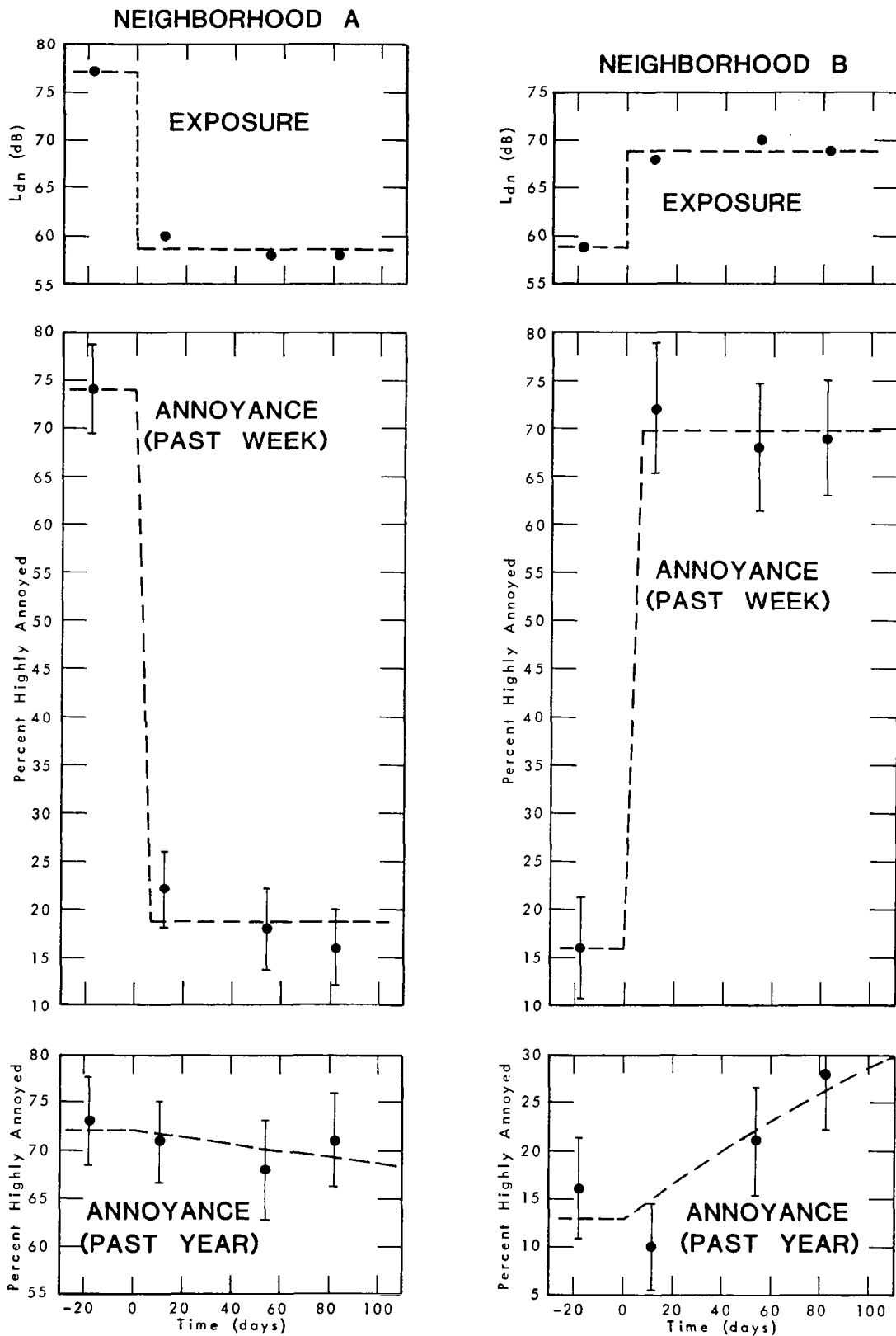
FIGURE 9.   OBSERVED HISTORY OF EXPOSURE AND ANNOYANCE.
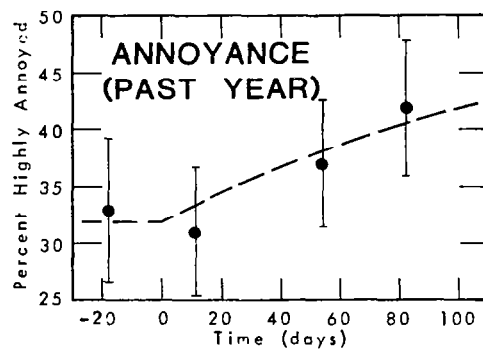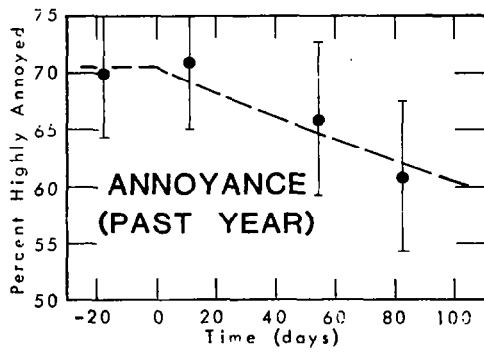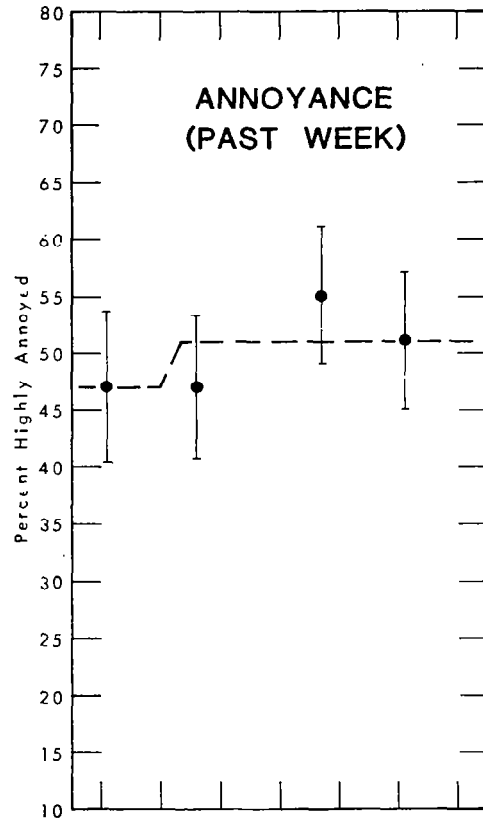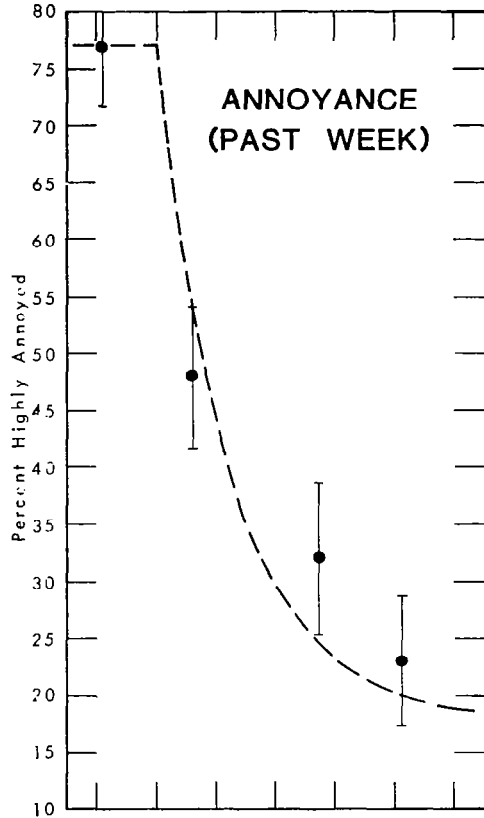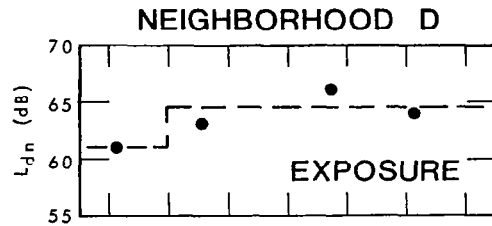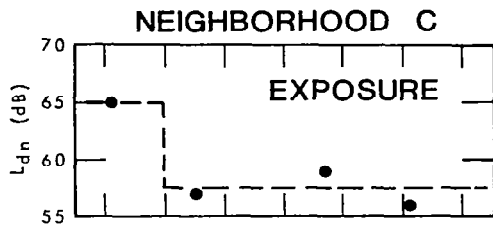
FIGURE 9. CONCLUDED.
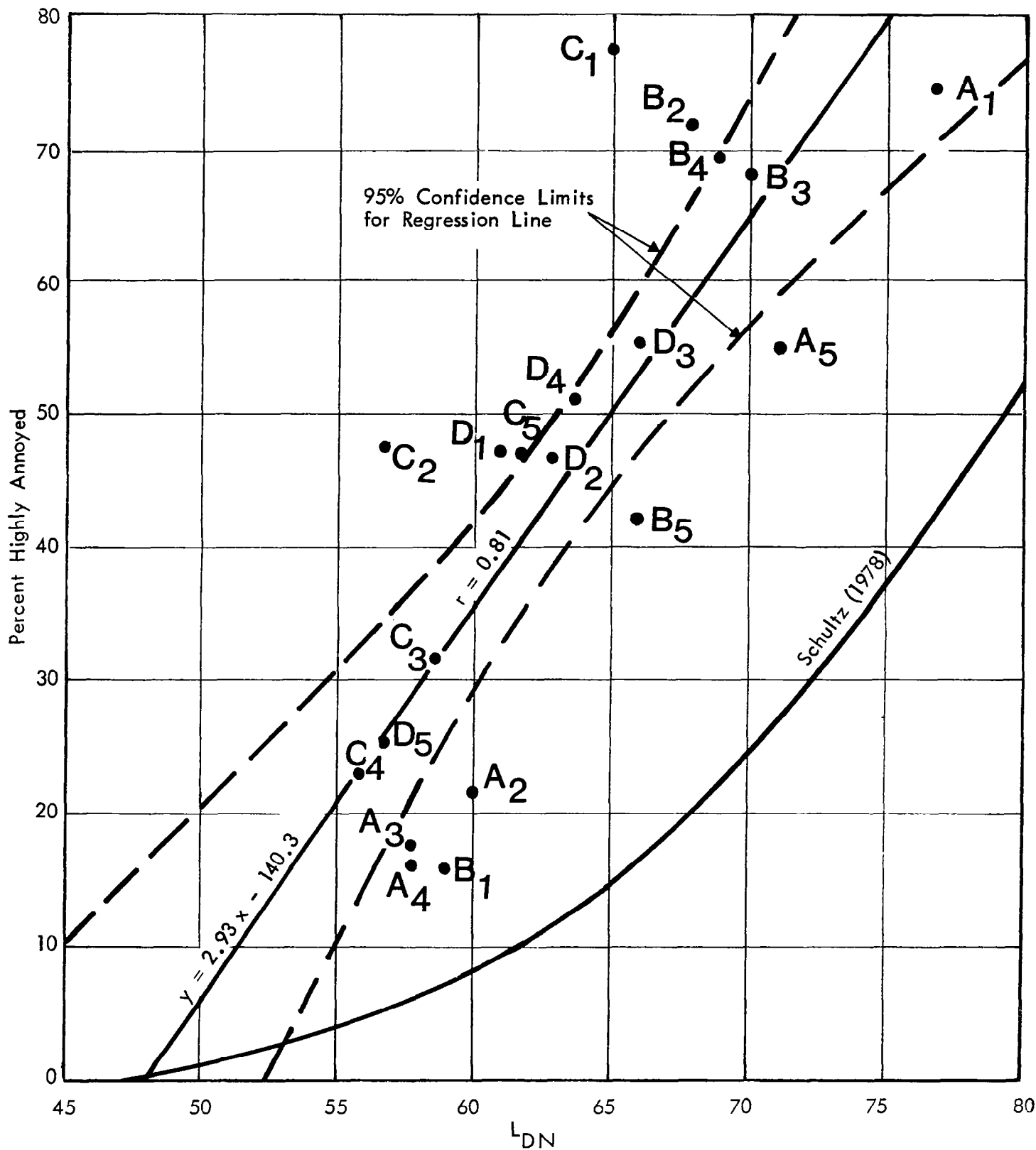
FIGURE 10. OBSERVED RELATIONSHIP OF IMMEDIATE ANNOYANCE AND NOISE EXPOSURE (QUESTION 3).

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noise. Note that even though the changes are not as dramatic
or immediate as the changes in short term annoyance, they
nonetheless reflect the direction and magnitude of changes
in exposure.

      b.   Relationship Between Weekly and Yearly
           Annoyance Due to Aircraft Noise

Correlations between weekly and yearly distributions of annoy-
ance due to aircraft noise were very strong in the first round
of interviews. Indeed, in the two neighborhoods (A and C)
most heavily exposed to aircraft noise before the closure of
Runway 15-33, the figures for yearly and weekly annoyance
were nearly identical (r = 0.997 and 0.991, respectively).
Slightly lower correlation was observed in Neighborhood B
(r = 0.908), which had no significant exposure from air
carrier operations prior to closure of Runway 15-33.
These high correlations provide assurance that there was
nothing peculiar about opinions during the week preceding
the first round of interviews.

In Neighborhood D, which had no significant exposure from
air carrier operations and even less exposure from general
aviation traffic than Neighborhood B, the correlation was
poor (0.206); the distribution of annoyance due to aircraft
noise for the week preceding the first round of interviews
was generally higher than for the year. In successive
rounds of interviews, the relationships between weekly and
yearly distributions of annoyance due to aircraft noise
changed dramatically. In Neighborhood B, for example,
the correlation changed from +0.908 for Round 1 to -0.73
in Round 2, -0.54 in Round 3, -0.49 in Round 4, and +0.49
in Round 5.

The fact that the correlations changed so greatly underscore the respondents' ability to distinguish between weekly and annual opinions.

5. Analyses of Responses to Question 5

Question 5 was included in the final round of interviews to explore the hypothesis that discrepancies in proportions of respondents highly annoyed by aircraft noise and similar proportions predictable from Schultz's (1978) relationship might be attributable to the presence of large numbers of general aviation operations at Burbank Airport. The question required respondents to estimate how many overflights of small general aviation aircraft in their neighborhoods were equally annoying as a single overflight by an air carrier aircraft. If people based their answers solely on single event exposure levels produced by the two types of aircraft flyovers, their answers would have been approximately 100:1, since overflights of transport aircraft produce single event noise exposure levels on the order of 20 dB greater than those of general aviation aircraft in the interviewing areas.

A sizeable proportion of respondents had difficulty either in understanding the question or in formulating a numerical response. Responses from 38% of all respondents were coded as "Don't Know" (i.e., unable to understand the question or provide an estimate). Another 11% of all respondents indicated that individual overflights by general aviation aircraft were either as annoying as or more annoying than individual overflights by air carrier aircraft. Figure 11 is a histogram of the numerical estimates of number of general aviation aircraft overflights made by the 43% of all respondents who were: (1) able to answer Question 5, and (2) who thought that a general aviation aircraft overflight was less annoying than an air carrier aircraft overflight.
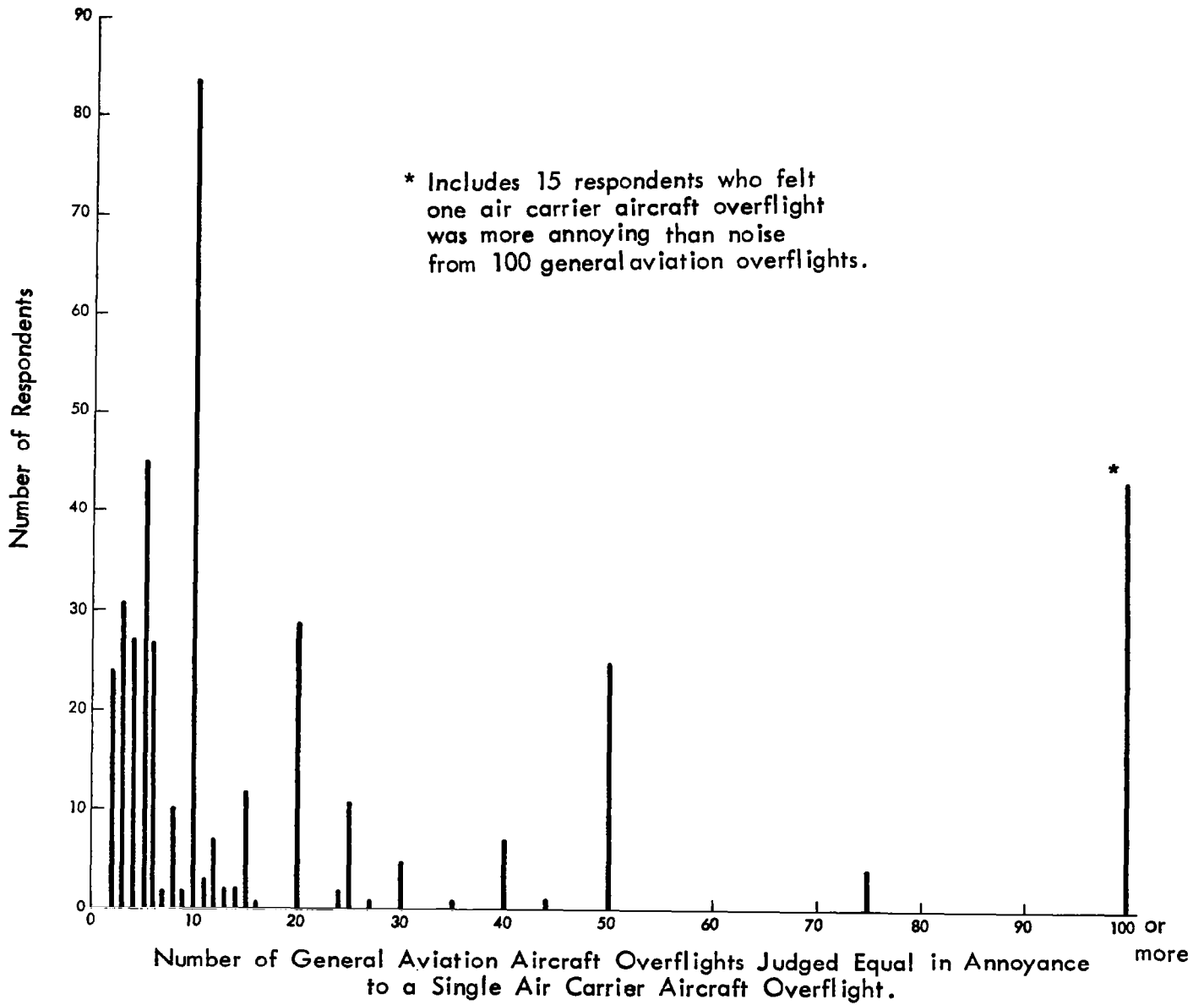
FIGURE 11.   RELATIVE ANNOYANCE OF OVERFLIGHTS OF
GENERAL AVIATION AIRCRAFT AND SINGLE AIR
CARRIER AIRCRAFT.

6. Analysis of Responses to Question 6

Question 6 was included in the final round of interviews to explore the hypothesis that discrepancies between the currently observed proportions of respondents highly annoyed by aircraft noise and similar proportions predictable from Schultz's (1978) relationship might be attributable to strong negative attitudes toward airport and airline management rather than purely acoustic factors. Figure 12 displays histograms of responses to this question by neighborhood. In general, the prevalence of unfavorable attitudes toward aircraft and airport operators reflected noise exposure levels.

7. Analyses of Demographic Effects

Responses to the key question (concerning annoyance due to aircraft noise during the week preceding the interview) were examined for evidence of effects of age and sex of respondents. Chi square tests of association were performed first in data aggregated over all neighborhoods and rounds of interviews. No significant differences were observed between the distributions of responses of male and female respondents, nor among respondents with estimated ages under 30 years, 30-50 years, and over 50 years.

More detailed chi square tests on data for separate rounds of interviews and neighborhoods revealed no other noteworthy differences in response distributions attributable to age or sex.

8. Analyses of Effects of Mode of Interviewing

Analyses similar to those described above were also performed on response distributions for Question 3 determined by personal
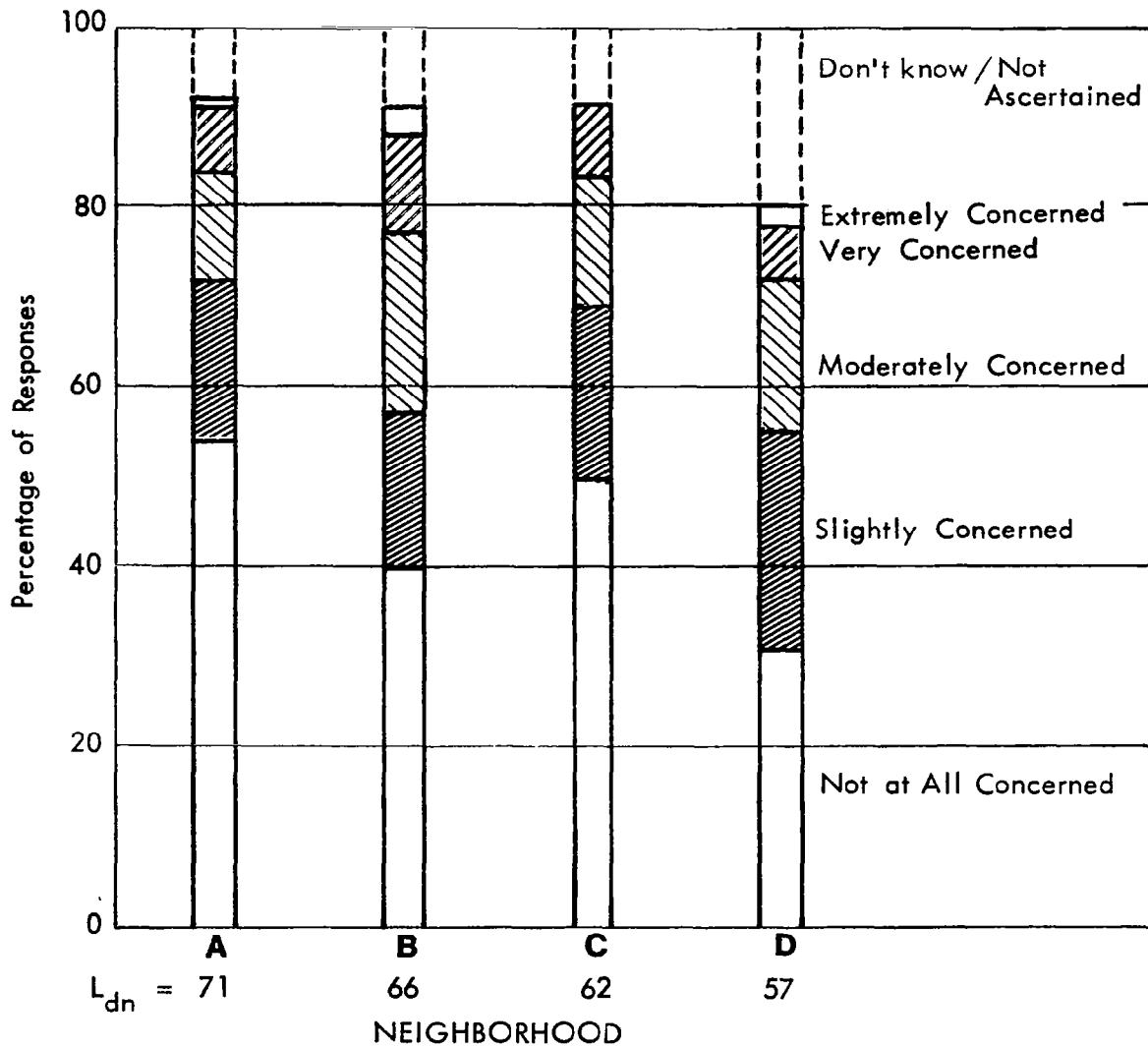
FIGURE 12. DISTRIBUTIONS OF REPORTED DEGRESS OF CONCERN OF AUTHORITIES FOR RESIDENTS' COMFORT.

(face-to-face) and telephone interviewing. No significant
differences were observed between the response information
derived from the two types of interviews.

IV. DISCUSSION

Several aspects of the current findings are noteworthy, as
are certain aspects of the study design that permit analyses
not hitherto employed in social survey research on community
reaction to noise exposure. Because these novel analyses
may be unfamiliar, they are described in detail in Appendices
C and F to supplement the following discussion.

A. Direct Evidence of Sensitivity to Changes in Aircraft Noise Exposure

Although Figure 9 shows similar patterns of changes in
exposure and annoyance, it is not clear from the figure
what processes are responsible for these findings. Logical-
ly, a sudden change in numbers of aircraft overflights could
increase the numbers of people reporting a high degree of
annoyance, decrease the number reporting a low degree of
annoyance, or perturb the distribution of degree of annoy-
ance over neighborhood residents in some other non-linear
fashion.

Responses to the question about annoyance due to aircraft
noise in the week preceding the interview provided the
clearest indication of sensitivity to physical exposure
parameters. This sensitivity is explored further in Appendix
C in the framework of the Theory of Signal Detectability. The
results indicate that changes in exposure do indeed relate to
changes in annoyance in the communities under study.

B. Relationship to Prior Findings

The disagreement apparent in Figure 10 between the current
data and the relationship of Schultz (1978) requires comment

at some length. The disagreement is substantial, since the relationship of Schultz lies well outside the 95% confidence interval for the regression line of the current data. Both procedural and substantive sources for the disagreement are discussed below.

1. Procedural Explanations

Whenever research fails to produce an expected finding, the first possibility to be considered is faulty technique or error of measurement. These potential explanations for the discrepancy may be rejected for reasons noted below.

a. Error of Physical Measurement

Consider first the possibility of error in physical measurement of aircraft noise levels. This explanation may be dismissed out of hand for several reasons:

(1) The automatic noise monitoring equipment gave no indication of malfunction or calibration drift that could have had any noticeable effect on the estimated aircraft noise exposure levels at the four interviewing sites.

(2) The interviewing sites were sufficiently small in area and homogeneously exposed to aircraft noise that it is extremely doubtful that the observed aircraft noise levels failed to represent the actual exposure at all residences at each site (see Appendix E).

(3) The aircraft noise exposure estimates developed from the computer-based analyses of the monitoring data faithfully reflect the known pattern of changes in aircraft operations, and are consistent with other measurements independently made for other purposes during the same time periods.

It is, however, possible to speculate about the possibility of a systematic underestimation of several decibels in traffic noise levels, attributable to the placement of microphones in backyards. Measurements of traffic noise on streets immediately in front of residences tend to be lower when made in backyards than when made at curbside or front facade measurement points. Not all traffic noise to which neighborhood residents are exposed is generated on adjacent block faces, however. The lack of standardized measurement points in the survey research summarized by Schultz (1978) precludes direct estimates of the effects of a potential underestimation of traffic noise levels on the relationship between the current data on annoyance due to traffic noise and the information developed by Schultz.

b. Errors of Social Measurement

The next possibility that may be rejected is error in social measurement. Among the reasons that errors of this sort may be dismissed are the following:

(1) Bias due to systematic under- or over-representation of certain subpopulations in the interviewing areas is an unlikely explanation for the present findings because the sampling procedures nearly exhausted the population available for interviewing.

(2) Bias due to unknown random errors is also an unlikely explanation, because the disagreements between the current data and those of Schultz (1978) are consistent in direction and uniform across interviewing sites. It is difficult to conceive of a random error in the current study that could have produced such a consistent pattern of disagreement with Schultz (1978).

(3) The same survey organization, using very similar tech-
niques, produced data on arcraft noise annoyance in good
agreement with Schultz (1978) in a nearby airport community
several years earlier (Fidell and Jones, 1973).

2. Substantive Explanations

The absence of compelling reasons to attribute the poor agree-
ment between the current data and Schultz's (1978) synthesis
to procedural matters forces consideration of substantive
bases for the disagreement. It should be understood from
the outset of this discussion, however, that the present data
do not by themselves indicate which (if any) of the potential
explanations offered is "best." Instead, the data support a
variety of interpretations, of which the "best" may emerge only
after general understanding of community response to noise
exposure improves. Alternative interpretations of the data
are discussed below in order of simplicity and plausibility.

> a. Differences in Background Noise at Burbank
>   and at Synthesis Sites

In his discussion of the scatter in social survey data on the
relationship between community noise exposure and prevalence
of annoyance, Schultz (1978) explicitly suggests that the
annoyance of aircraft noise exposure in a community may
depend on the amount of traffic noise exposure. Schultz
(1978, p. 384) shows in his Figure 9 the results of a Swiss
aircraft noise survey, in which differences in percentages of
the community highly annoyed by the same aircraft noise expo-
sure as great as 40% were reported in neighborhoods with dif-
ferent traffic noise exposure.

Figure 13 shows the relationship between the current data and
the relationship between annoyance and noise exposure for light

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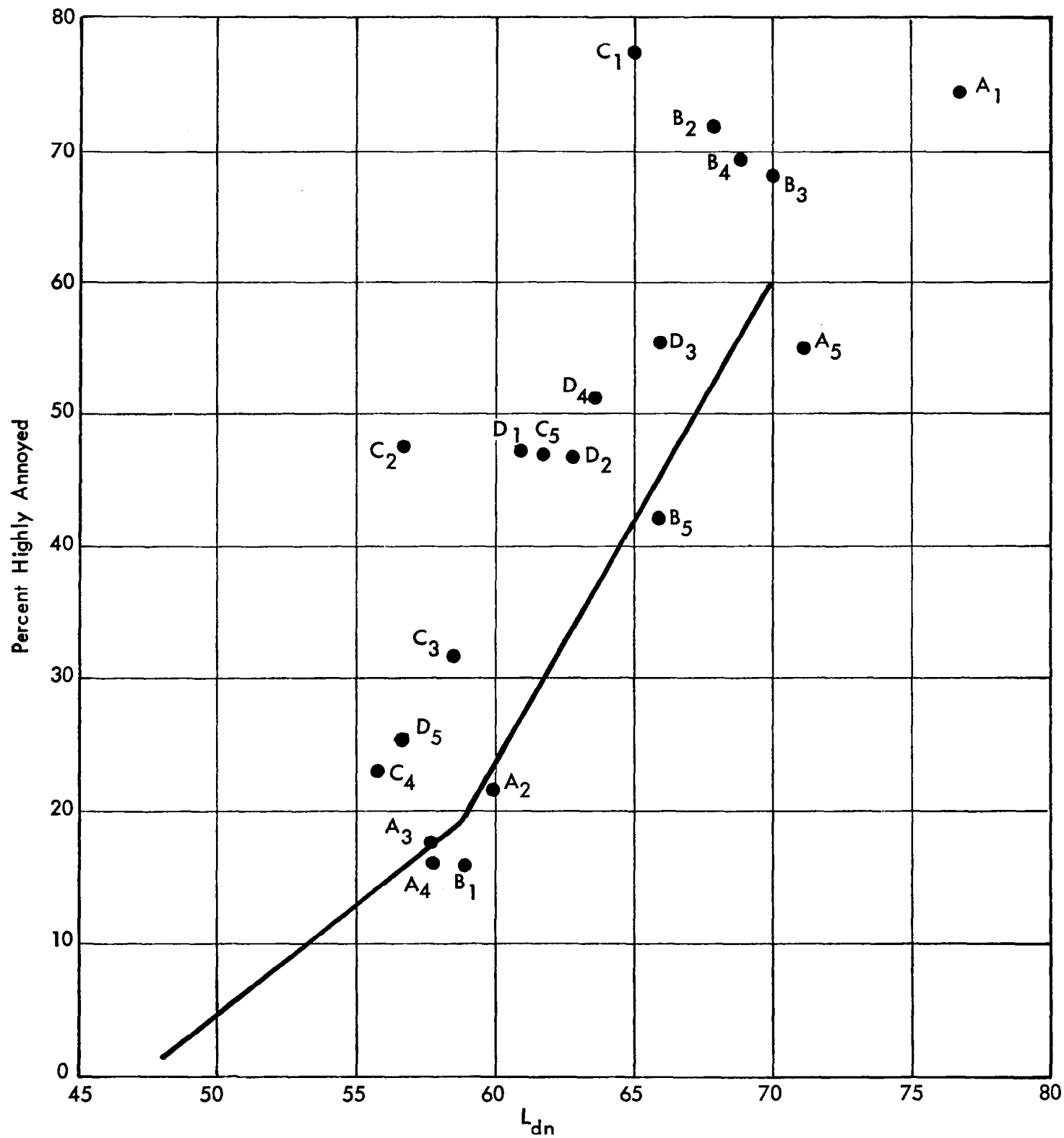
FIGURE 13. CURRENT DATA COMPARED WITH RELATIONSHIP
INFERRED FROM SWISS AIRCRAFT NOISE SURVEY
(LIGHT TRAFFIC).

traffic noise exposure observed in the Swiss study. The measured traffic noise levels at Burbank Airport (L_{dn} on the order of 50-55 dB) appear fairly similar to those reported by the Swiss (L_{50} between 40-52 dB).

Clearly, the relationship between exposure and annoyance for the light traffic noise exposure case seen in Figure 13 comes considerably closer to the present data than does the synthesis relationship. Attributing this closer agreement to the influence of traffic noise is not unreasonable, since the bulk of the aircraft annoyance data from the eleven clustering surveys in Schultz's synthesis was collected in neighborhoods surrounding major international airports, near which traffic noise levels considerably higher than those near Burbank Airport probably prevail.

Additional support for the plausibility of this background noise level hypothesis is provided by the observations of Waters and Bottom (1971), and the empirical evidence of Fidell, et al. (1979) on the relationship between detectability and annoyance of community noise. For the same L_{dn}, residents in neighborhoods near Burbank Airport may simply have heard more overflights than the people whose opinions are summarized in Schultz's synthesis.

b. Differences in Dosage-Response Relationships for Different Noise Sources

It is sometimes contended that the prevalence of annoyance due to noise exposure in a community may depend for a variety of reasons on the source of that exposure. These reasons range from the nature of the exposure to individual attitudes toward operation of noise sources. Hall et al. (1981) are proponents of the position that for the same integrated noise exposure, greater percentages of people will be highly annoyed by aircraft noise than by traffic noise.

Figure 14 shows a relationship between aircraft noise exposure and prevalence of high annoyance derived by Hall et al. (1981). As was the case in Figure 13, Schultz's (1978) synthesis curve does not agree with the present data as well as the alternative relationship plotted in the figure. It is not clear whether the fit of Hall's aircraft noise relationship to the present data is merely fortuitous, or whether it should be interpreted as support for the position that decibel for decibel, aircraft noise is more annoying than traffic noise. The scatter in the data from which Hall derived his relationship is considerable, and Hall's estimates of aircraft noise exposure responsible for observed annoyance may be in error by several decibels.

c. Politicization of Community Response to
    Aircraft Noise Exposure

Airport noise-related issues have been prominent community concerns in the vicinity of Burbank Airport for many years. Litigation seeking redress for past exposure and limits to further exposure, disputes between the airport operating authority and airlines, and the terms of the recent sale of the airport from a private to a public agency, have all been extensively publicized. Intuitively, all of this attention seems likely to have a sensitizing influence on the prevalence of self-reported annoyance.

One interpretation of the greater prevalence of annoyance for the same exposure levels in the present data than in Schultz's synthesis might therefore be that the present data reflect a general increase in awareness of aircraft noise. Some support for this interpretation may be found in the observation that well over half of the respondents in all neighborhoods felt that airport and airplane operators cared not at all, or only slightly, for their comfort (see Figure 12). Such attitudes
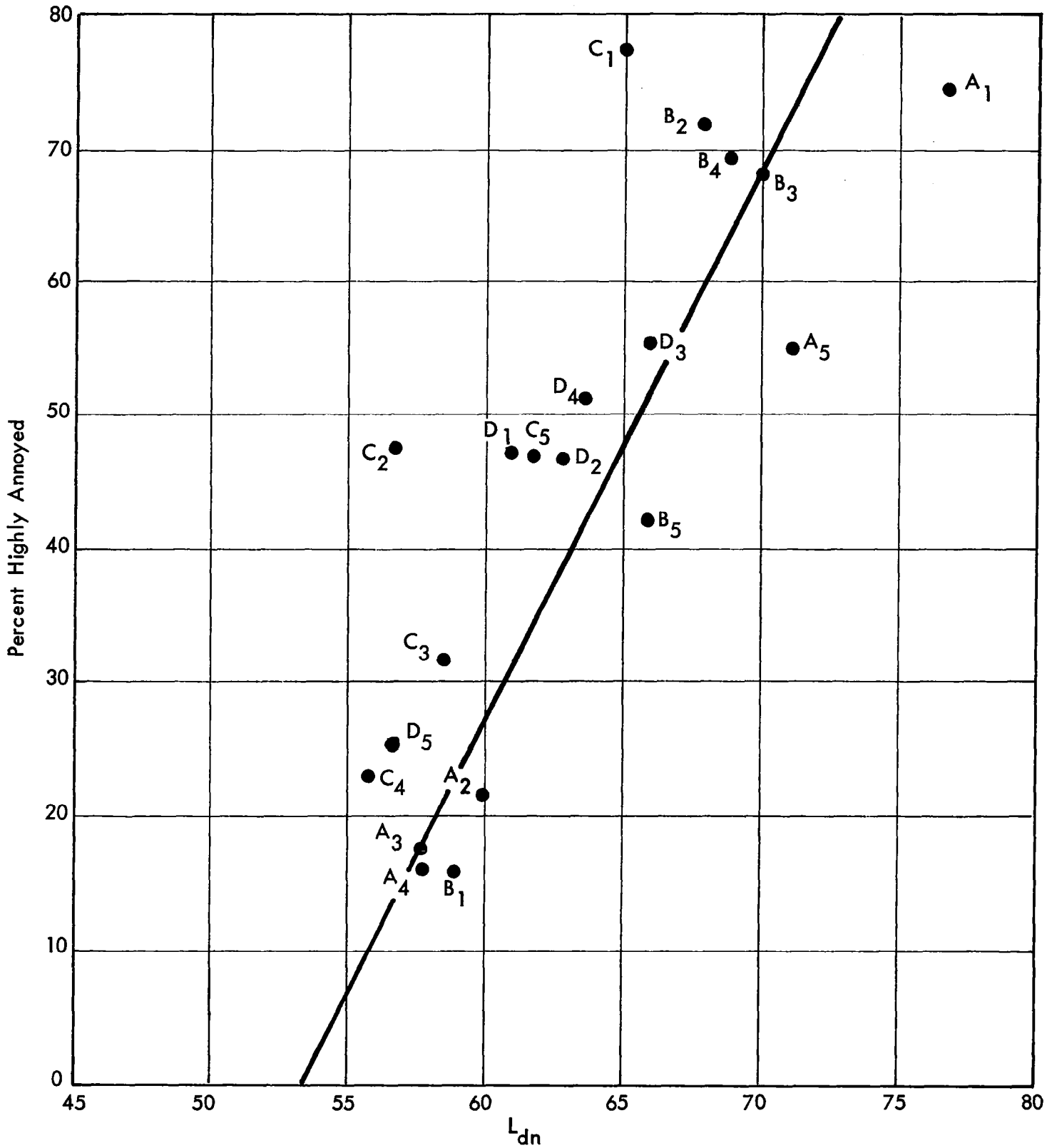
FIGURE 14. CURRENT DATA COMPARED WITH RELATIONSHIP INFERRED BY HALL (1981).

seem consistent with a general arousal of adverse opinion
about aircraft noise. It might also be that the changes
in exposure patterns themselves drew unusual attention
to aircraft noise.

By similar reasoning, the greater prevalence of annoyance
with aircraft noise in the present survey might also
reflect the community's anticipatory reactions to feared
increases in aircraft noise exposure. In this view, the
community's reactions to traffic noise are similar to the
views expressed in many other communities, because there
is little realistic basis for fear of great increases in
traffic noise in the vicinity of Burbank Airport. The
community's reactions to aircraft noise exposure, however,
may be more intense that those expressed in communities
in which there is little prospect for future increases in
aircraft noise exposure. Fears of increases in aircraft
noise exposure may not have been as pressing in the communi-
ties in which the data summarized by Schultz (1978) were
collected.

The difficulty with intuitive explanations of the sort
discussed in this subsection is that they are essentially
non-quantitative, and do not admit readily of empirical
test. The validity of such explanations is thus likely
to remain in doubt for the foreseeable future.

    d. Appropriateness of the Metric of Noise Exposure

The preceding discussion has sought explanations for the
ill fit between Schultz's synthesis and the current data
along the ordinate of Figure 10. The following discussion
draws attention to the abscissa of the figure.

The first point to be made is that the quality of physical measurement in some earlier aircraft noise survey research is very uneven. It may be that some of the disagreement in dosage-effect relationships of the current study and of that derived by Schultz is due to errors of measurement in the prior work.

It is also possible, however, that integrated energy measures of aircraft noise exposure are ill suited to characterizing the aircraft noise dose of communities near mixed-use airports. L_{dn} values in the interviewing areas were dominated by the small minority of flights by air carrier aircraft at Burbank Airport.

The majority of the flight activity at the airport by general aviation aircraft escaped quantification by L_{dn} (because of its 20 dB lower single event level), even though such flights were clearly audible. The bimodality of the distributions of aircraft noise levels that may be seen in some of the figures of Appendix D demonstrates this effect.

If the intensity of community reaction to aircraft noise is even partially related to the number of aircraft noise intrusions experienced daily, then L_{dn} may be a poor metric of noise exposure at Burbank Airport, even though it might be entirely adequate in an airport with more homogeneous flight operations. Thus, Schultz's (1978) synthesis may simply be inapplicable to the current data because of the inappropriateness of the metric of the abscissa. Rice (1980, Figure 6) has reported analyses that suggest that numbers of annual airport operations (and hence, perhaps, aircraft mix) may

affect dosage response relationships reported in
terms of L_{dn}.

C. Changes in Long Term Assessment of Noise Exposure

An issue of concern to agencies responsible for policy
decisions about aircraft noise exposure is the amount of
time that must pass after a major change in a community's
noise exposure before stable estimates of community
reaction to the changed exposure can be made. Estimates
of the rates at which respondents in the four neighborhoods
changed their long term opinions about aircraft noise
exposure were made by assuming that these opinions changed
at an exponential rate.

The general form of the exponential relationship between
change in output as a function of change in input for
the assumed process is:

$$P(t) = P(\infty) + \Delta P . e^{-t/T}$$

where:　　　t = elapsed time since noise exposure change,
in days

T = time constant of attitude change, in days

$P(t)$ = percent highly annoyed at time t

$P(\infty)$ = percent highly annoyed after long term
adaptation to changed noise exposure

ΔP = difference between percent highly annoyed
after exposure change and long after change.

Appendix F contains details of the application of this
analysis to the current annoyance data. Several observa-
tions may be made about the time course of change of
long term attitudes toward aircraft noise exposure
despite the variability in estimates of the time
constant documented in Appendix F.

First, the most likely value of the time constant is on
the order of two to ten months. Second, in communities
where the noise exposure has been particularly high
(e.g., Neighborhood A) a saturation effect may occur,
such that people do not soon forget their past environ-
ment, thus producing particularly long time constant
estimates. The data of this study are too limited by
themselves to make stronger statements about the
dependence of T on direction of exposure change or
absolute level (either daily average or individual
event).

D. Prevalence of Annoyance in Four Neighborhoods

Figure 10 shows the prevalence of high annoyance in all
neighborhoods during all time periods. As noted earlier,
these data do not correspond closely to the relationship
synthesized by Schultz (1978). This does not imply that
responses of communities to changes in aircraft noise
exposure are inconsistent or unpredictable, however.

Replotting the data of Figure 10 in Figure 15 makes this
point more clearly. Shading is used in Figure 15 to
emphasize the regularity of the data in the four separate
neighborhoods over the five rounds of interviewing. Within
each shaded area, sizeable increases or decreases in expo-
sure are accompanied by large changes in the prevalence
of annoyance. The results for the first round of inter-
viewing (before exposure changes) are highlighted by solid
square symbols. Arrows point to the results of the second
round (first interview after change).

Although Figure 15 shows consistency of responses *within*
neighborhoods, it also shows differences *among* neighborhoods.
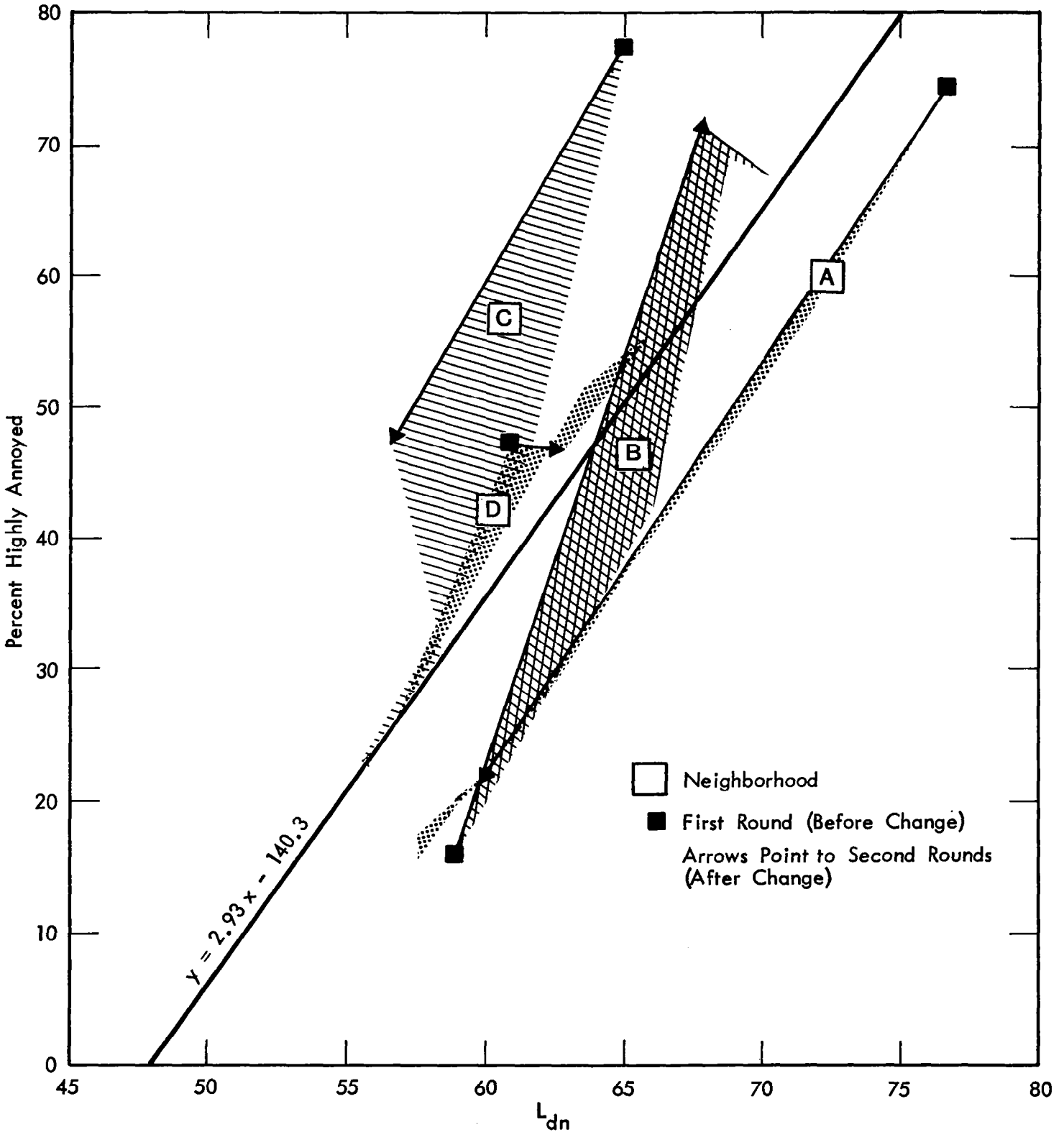
FIGURE 15. ANNOYANCE AND NOISE EXPOSURE FOR
DIFFERENT NEIGHBORHOODS.

In the first round of interviews, for example, two neighbor-
hoods (A and C), differed in exposure by about 12 dB, but
did not differ meaningfully in prevalence of high annoyance.
In fact, the proportion highly annoyed in Neighborhood A
(0.74) lies well within the 95% confidence interval
(0.70 to 0.84) for the proportion highly annoyed in
Neighborhood C. Similarly, Neighborhoods B and D in
Round 1 differed by only 2 dB in exposure, but by approxi-
mately 30% in pervasiveness of high annoyance. The pro-
portion highly annoyed in Neighborhood D (0.47) lies well
outside the 95% confidence interval for the proportion
highly annoyed in Neighborhood B (0.09 to 0.23).

The results of the second round of interviewing compared
to the first (arrowed lines for each neighborhood) certainly
indicate that any substantial change in exposure level
produces a change in the percentage of people reporting
high annoyance. Further comparison of the first two rounds
of interviewing suggests that a decrease in exposure (neigh-
borhoods A and C) produces less change in annoyance than an
increase in exposure (neighborhood B). However, this dif-
ference may be related to neighborhood or previous exposure
conditions, especially since the increasing and decreasing
annoyance/exposure slopes appear very much the same within
neighborhoods.

The shaded areas in the figure are relatively narrow,
indicating a small variation in response to exposure within
each neighborhood. Exceptions do exist, especially in area
C. However, the responses as a whole show less variability
when grouped by neighborhood than when ungrouped.

The regression line for all of the data (shown originally
in Figure 10) is presented again in Figure 15. Even though

the difference in response between neighborhoods is apparent,
the responses for each neighborhood are still reasonably
represented by the regression line through all of the data.

V. CONCLUSIONS

1. The magnitude and direction of change in proportions
of the community highly annoyed by aircraft noise in the
weeks preceding each of five rounds of interviewing were
highly correlated with changes in physical exposure.

2. Observed percentages of respondents highly annoyed
by traffic noise exposure were somewhat higher than those
predicted by Schultz (1978).

3. Observed percentages of respondents highly annoyed
by aircraft noise exposure were much greater than pre-
dicted by Schultz (1978).

4. Changes in the prevalence of annoyance following
changes in aircraft noise exposure were attributable
directly to exposure effects rather than to changes in
criteria for reporting annoyance.

5. At least two months must elapse following changes
in aircraft noise exposure of the magnitude observed in
the current study before the proportion of the community
highly annoyed by the changed exposure begins to stabilize.

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APPENDIX A

DETAILS OF NOISE MEASUREMENT PROCEDURES

NOISE MONITOR INSTRUMENTATION

The noise monitor units used in this study are the BBN Model
704 and 614 systems designed especially for unattended moni-
toring of aircraft and community noise over long periods of
time. The units are capable of operating for several days un-
attended; however, routine calibration is performed every other
day to insure data accuracy. In this particular study the
Model 704 monitored aircraft noise intrusions, while the Model
614 measured the ambient noise environment.

A. Model 704

Figure A-1 shows the Model 704 in field service. The Model 704
unit consists of a General Radio, 1/2-inch electret microphone,
monitor control unit and digital cassette tape recorder.

The unit also incorporates a small keyboard by which annotation
(such as site location, date, instrumentation serial numbers,
etc.) may be directly coded on the digital magnetic tape.

The monitor can operate in one of two user-selectable configura-
tions, "time history mode" or "statistical mode", depending upon
the particular application involved. In time history mode, the
history of individual noise intrusions (such as aircraft flyovers)
is retained. Statistical mode provides detailed statistics of

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Use of trade names or names of manufacturers in this report does not
constitute an official endorsement of such products or manufacturers, either
expressed or implied, by the National Aeronautics and Space Administration.
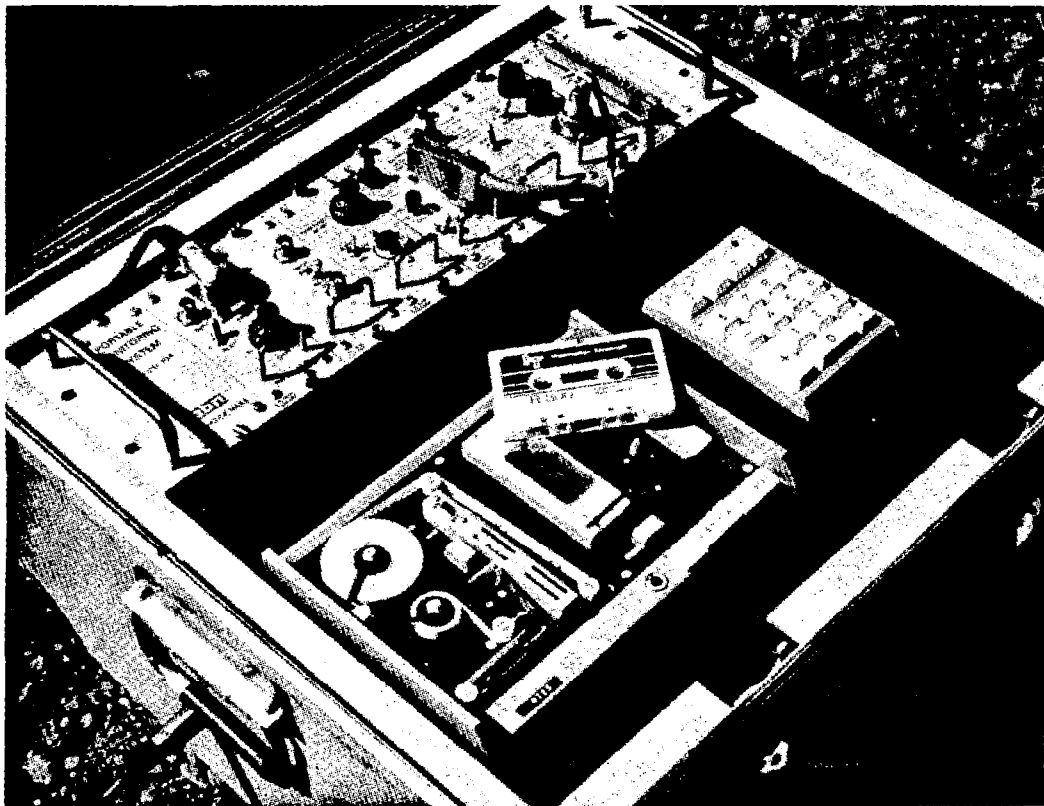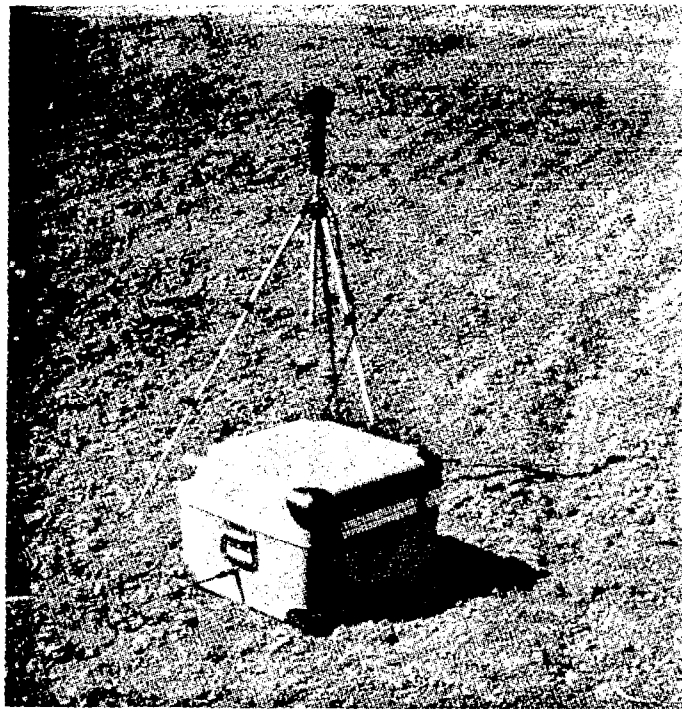
FIGURE A-1.   MODEL 704 NOISE MONITOR.

hourly sound levels at the expense of losing the identity of individual events. "Time history" mode was used in this study.

The entire system meets Type 1 sound level meter specifications. All data were recorded using the A-weighting network and "slow" meter dynamics. The digital cassettes retrieved from the units were sent on a digital computer to our laboratory for analysis. The summary data provided by the computer forms the heart of the information gathered in this study.

A block diagram of the unit operating in "time history" mode is shown in Figure A-2. In this mode operation is controlled by a user-selectable sound level threshold. During periods when the sound level does not exceed the threshold, the monitor unit remains in a quiescent state. However, when an aircraft or other transient noise intrusion occurs and the sound level rises above the preset threshold value the sound level is digitized and recorded on digital tape. The monitor unit continues to digitize the recording at a one second rate as long as the threshold is exceeded. When the sound level drops below the threshold value, sound level recording ceases and the time-of-day is recorded on the tape (from an internal digital clock). The significant noise intrusions and their time of occurrence are recorded. This mode of operation is consistent with state airport noise regulations and provides a means for separating the lower level background noise environment from the higher aircraft noise levels. The dynamic range of the instrument is 100 decibels.

Windscreen

GR 1962-9601
Electret Microphone

GR 1560-P42
Microphone Preamplifier

Calibrator
GR 1562 A

BBN 704 NOISE MONITORING UNIT

Input
Amplifier

A-Weighting
Network

Log
Converter

Threshold
Detector

Digital
Clock

Analog to
Digital
Converter

Switch

Annotation
Keyboard

Digital Cassette
Recorder
MSI 2001
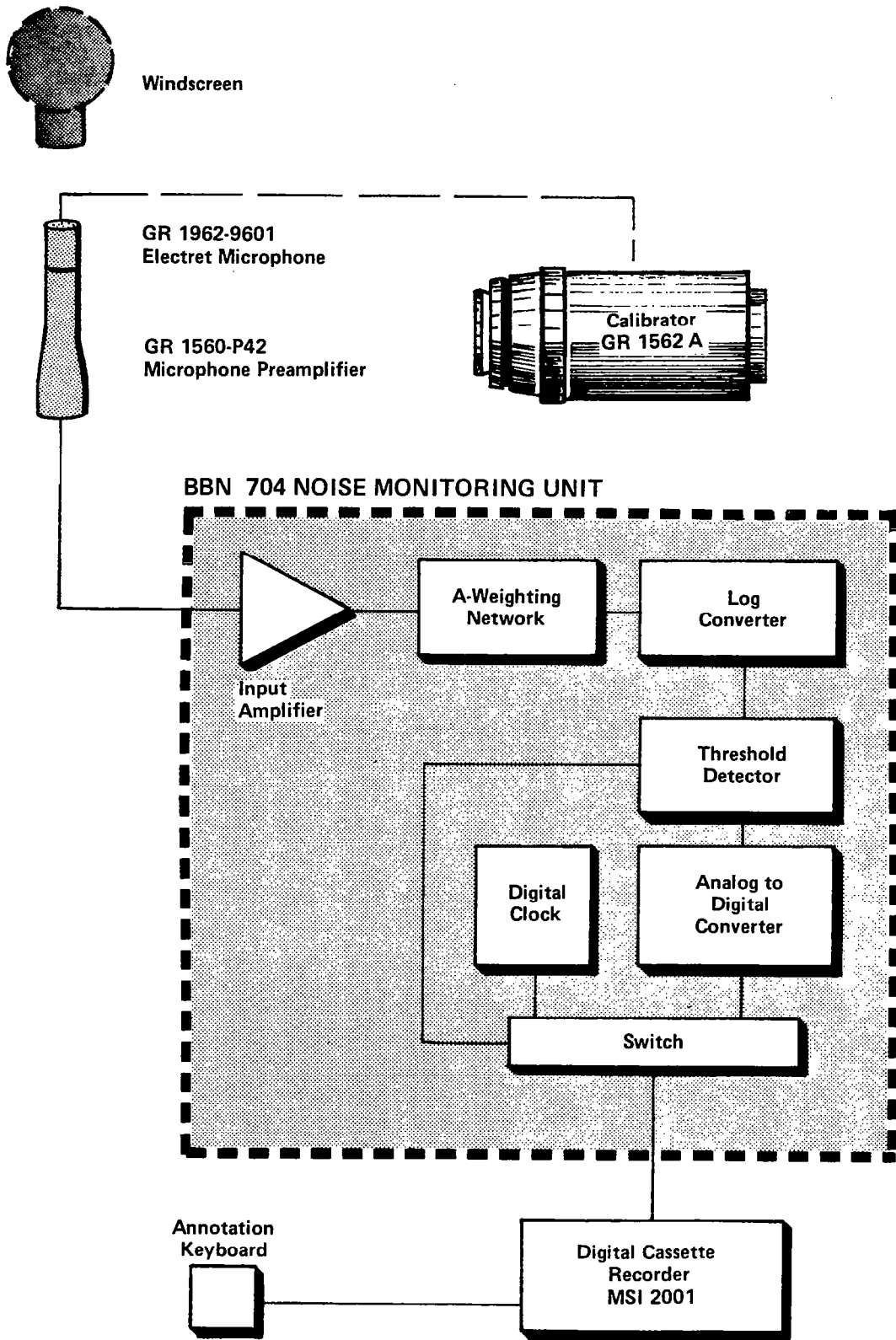
FIGURE A-2.   BLOCK DIAGRAM OF MODEL 704 NOISE
MONITOR LOGIC.

The digital tapes recorded by the monitor are processed by a Digital Equipment Corporation PDP-8 computer to provide single event, hourly, and daily statistics.

A typical computer printout is shown in Figure A-3. Note that for each noise intrusion, the time of day, the maximum level, the time duration for which the level is within 10 decibels of the maximum value, and the single event noise exposure level (SENEL) are tabulated. In addition the hourly noise level (HNL) is tabulated at the end of each hour. Finally, at the end of each day, the community noise equivalent level (CNEL) and day-night average level are listed.

The effect of the digitization process on computed sound exposure level (SEL) accuracy is shown in Figure A-4. Within the monitor, the output of the microphone is converted by analog circuitry to a time-varying DC voltage proportional to the A-weighted, slow-response sound level in decibels. At a fixed period rate (in this study once per second), the instantaneous DC voltage is digitzed (in this study to a resolution of 1 decibel) and recorded on digital tape. Later, the tape is processed by a digital computer which computes the sound exposure level of each noise event by an energy summation of these digitized levels. Figure A-4 shows the ±95 percent confidence interval on the computer SEL as a function of signal duration 10 dB down from the maximum value at 3 different digitization rates (the middle curve applies to this study. Basically, the graph ascribes numerical values to common sense expectations. At very long durations (e.g., 60 seconds or greater) the signal rises and decays slowly with time, and the probable error is

```
        TIME       MAX    DUR  SENEL
      20:14.5   77.0      6    82.0
     <20:33.1   72.0      4    77.3
      20:38.8   79.0      9    84.2
      20:51.9  102.0      7   107.5
     <20:52.2   75.0     14    84.1
   $ HNL  (2000 TO 2059)  =   72.0


        TIME       MAX    DUR  SENEL
      21:49.8  103.0      5   108.2
     <21:51.7   73.0      3    76.9
      21:56.3  102.0      7   108.1
   $ HNL  (2100 TO 2159)  =   75.6
   $ HNL  (2200 TO 2259)  =   41.1
   $ CNEL (08 SEP   1979) =   76.1
   $ LDN  (08 SEP   1979) =   75.2



   $ DATE:  09 SEP   1979


        TIME       MAX    DUR  SENEL
     <02:00.8   76.0     10    84.0
   $ HNL  (0200 TO 0259)  =   48.4
   $ HNL  (0600 TO 0659)  =   29.4


        TIME       MAX    DUR  SENEL
     <07:09.9   76.0      8    82.9
      07:10.9  107.0     10   113.9
      07:14.7   98.0      9   105.3
     <07:22.5   75.0     12    81.6
      07:23.4  105.0      8   111.6
     <07:42.9   71.0      8    78.5
      07:43.5   99.0     11   106.8
   $ HNL  (0700 TO 0759)  =   81.2


        TIME       MAX    DUR  SENEL
      08:05.5   81.0     10    87.6
     <08:09.1   76.0     11    84.2
     <08:10.3   73.0      6    79.8
      08:16.3   98.0     10   105.5
     <08:20.9   72.0      1    73.0
     <08:29.8   77.0     12    84.4
      08:32.2   76.0      8    81.8
     <08:33.9   75.0      7    81.4
     <08:35.1  ·75.0      6    80.5
      08:40.8   94.0      7   100.5
```

FIGURE A-3.   TYPICAL OUTPUT FROM MODEL 704 NOISE MONITOR.
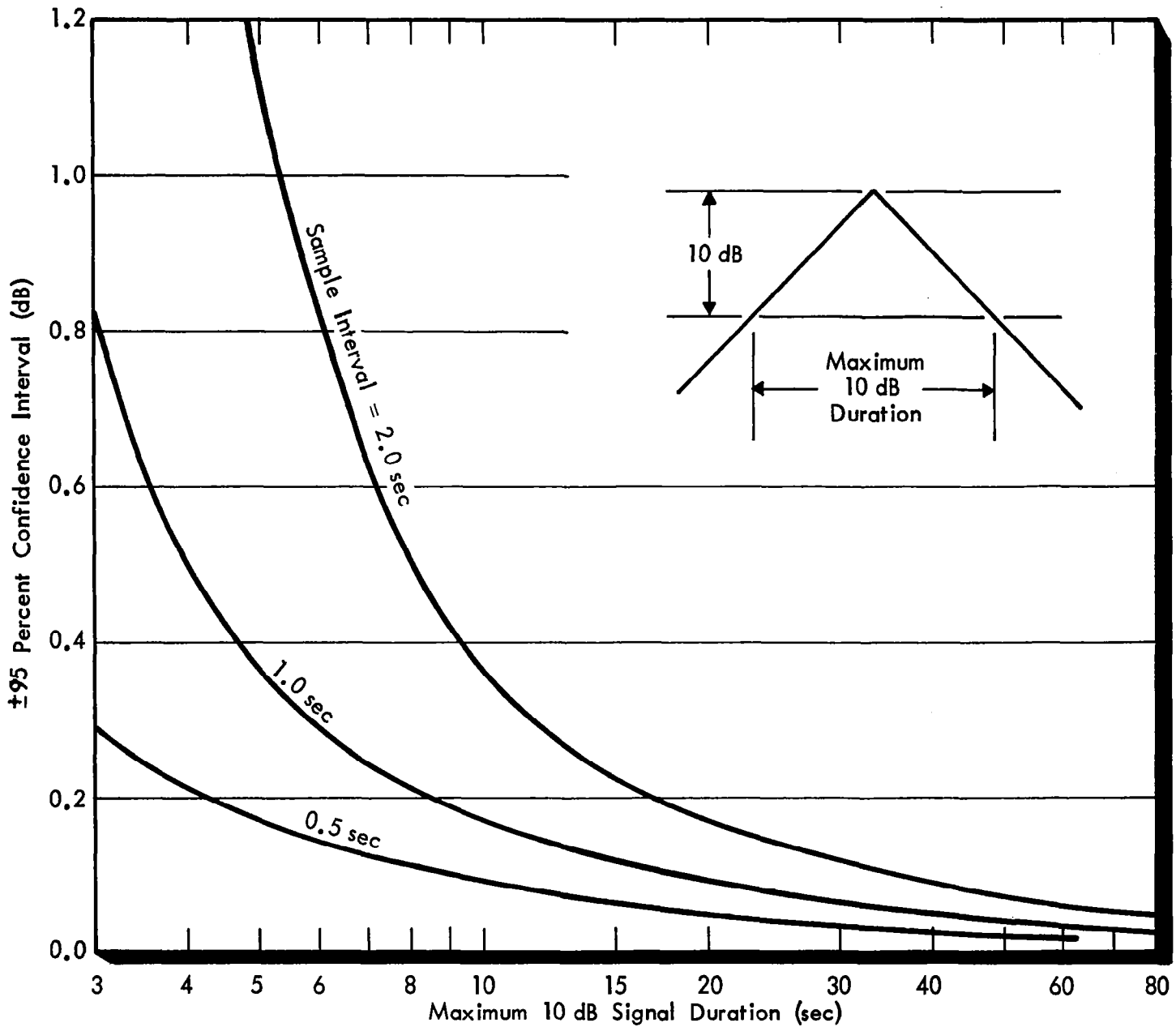
FIGURE A-4. SOUND EXPOSURE LEVEL COMPUTATIONAL ERROR BOUNDS DUE TO FINITE SAMPLING RATE (1 dB SPL RESOLUTION).

less than ±0.1 dB due to the large number of individual sound
levels incorporated in the summation. In contrast, the probable
error increases for short duration (fast rise/decay) signals
since fewer digitized sound levels contribute to the sum.
In this case the value of the sum becomes more sensitive to
the precise instant at which the sound level was digitized by
the monitor.

All things considered, however, the 95 percent confidence
interval does not grow excessively large even for relatively
short durations. For example, the interval is less than ±0.5
dB for all durations in excess of 4 seconds. By way of com-
parison, a review of the noise monitor data at sites nearest
the airport reveals that durations less than 6 or 7 seconds
are rarely observed.

B. Model 614

Figure A-5 shows the Model 614 in field use. The Model 614
field unit consists of a General Radio, 1/2-inch electret
microphone and monitor control units. The monitor contains
a microprocessor computer and printer so that sound level
information can be displayed directly in the field.

In the configuration used in this study, the unit records the
total noise environment (i.e., there is no threshold discrimina-
tion). A-weighted sound levels are digitized to the nearest
0.2 dB twice per second by the processor and accumulated over
a 1 hour period. At the end of the hour, the hourly noise
level (HNL) is calculated and printed along with the L_{99}, L_{90},
L_{50}, L_{10}, and L_5 centile levels and the maximum sound level.
The community noise equivalent level (CNEL) and day-night
average level (DNL) are calculated and printed at the end of
each day.

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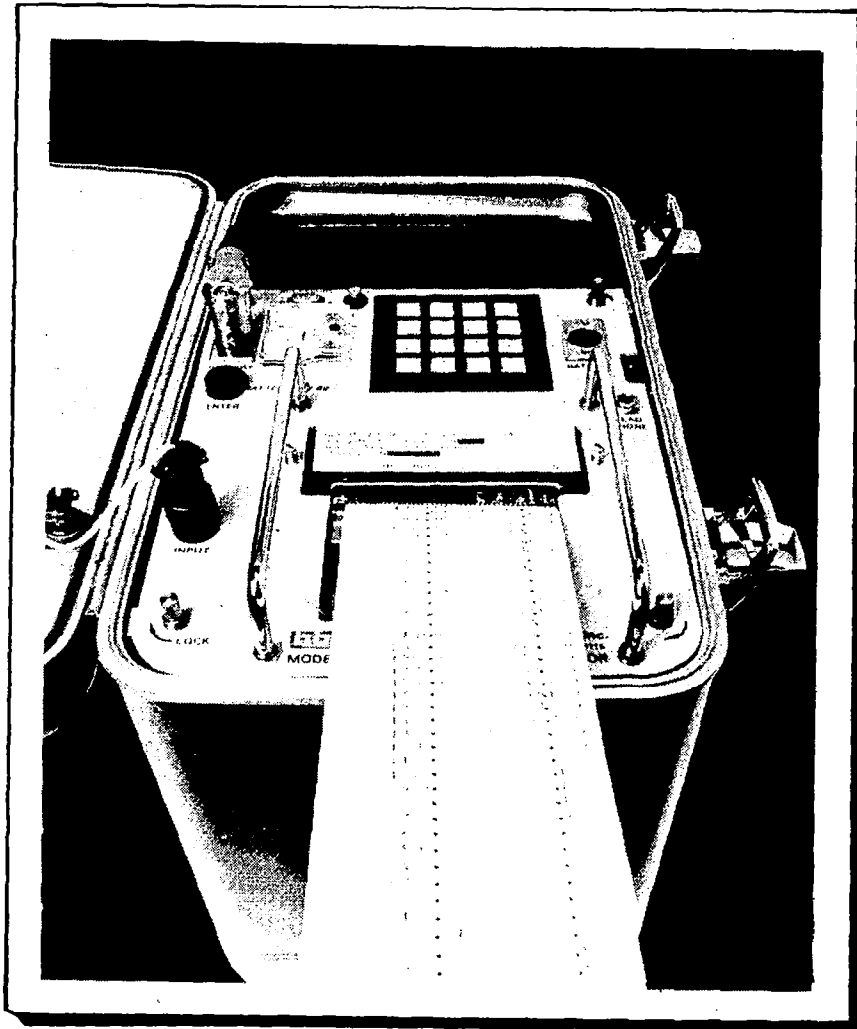
FIGURE A-5. MODEL 614 NOISE MONITOR.

Typical output for a one-day period is shown in Figure A-6.
For ease of identification each HNL is followed by the letter
"H", the CNEL followed by the letter "C", and the DNL followed
by the letter "d". The indicated times are the end of the
hour for which the HNL is reported.

```
 42  44  47  51  58  620 %
 00000 3    04  000  0493  F
 00000 2    04  000  0688  d
 00000 1    04  000  0695 C
 00000 0    04  000  0493  H
 43  44  47  50  59  680 %
 23000 1    04  000  0498  F
 23000 0    04  000  0498  H
 43  45  49  55  74  880 %
 22000 1    04  000  0633  F
 22000 0    04  000  0633  H
 45  47  49  52  68  870 %
 21000 1    04  000  061.5  F
 21000 0    04  000  061.5  H
 46  48  50  59  86  920 %
 20000 1    04  000  0708  F
 20000 0    04  000  0708  H
 47  49  53  58  82102 0 %
 19000 1    04  000  0746  F
 19000 0    04  000  0746  H
 51  52  55  59  74  890 %
 18000 1    04  000  0645  F
 18000 0    04  000  0645  H
 51  52  55  60  87  970 %
 17000 1    04  000  0735  F
 17000 0    04  000  0735  H
 51  52  54  57  72  91.0 %
 16000 1    04  000  0633  F
 16000 0    04  000  0633  H
 50  51  53  57  72  91.0 %
 15000 1    04  000  0650  F
 15000 0    04  000  0650  H
 45  47  50  60  87  970 %
 14000 1    04  000  0729  F
 14000 0    04  000  0729  H
 46  47  49  54  72  860 %
 13000 1    04  C00  0624  F
 13000 0    04  000  0624  H
```

STATISTICS FOR END OF DAY

DNL

CNEL

STATISTICS FOR HOUR ENDING AT 20:00

Centiles 99, 90, 50, 10, 1 and Max

L_{eq}

FIGURE A-6.   TYPICAL OUTPUT FROM MODEL 614 NOISE MONITOR.

APPENDIX B
TABULATIONS OF DATA

Table B-1 accounts for all completed and attempted inter-
views in the manner suggested by Kish (1965). More than
5,000 interviews were completed all told, about 52 percent
with female respondents, and 46 percent with male respondents.
About three quarters of these interviews were conducted in
person, and one quarter by telephone.

The major reason for non-completion of an interview was
unavailability of a telephone listing following an initial
attempted personal contact, listed as "unlisted" in Table
B-1. Failure to reach a potential respondent after four
callbacks, shown as "unreached" was the next most common
reason for non-completion. Language problems precluded only
242 interviews. Refusals to complete an interview totalled
only 816, only 12% of all contacts that could have led to a
completed interview.

Questionnaire data were keypunched, proofread, edited, and
submitted for tabulation to standard statistical software.
Summaries of responses to each question for each round of
interviews and each site are listed in Tables B-2 through
B-7.

Table B-8 summarizes auxiliary information collected in
the course of interviewing.

TABLE B-1

ACCOUNTING OF RESPONDENT CONTACTS
(All Figures are Percentages)

Neighborhood	A					B				
Round	1	2	3	4	5	1	2	3	4	5
Responses: F/F	52	61	43	49	47	36	36	40	46	47
Tel.	17	12	21	17	13	19	13	24	10	8
Total	69	73	64	66	60	55	49	64	56	55
Non-Responses:										
Unlisted	17	13	22	17	21	27	31	22	27	25
Unreached	2	5	3	4	5	1	4	3	5	11
No English	2	1	1	1	1	1	1	4	2	1
Other	1	1		1	1	1	1		1	1
Refusal	9	8	9	11	13	13	12	7	9	7

Neighborhood	C					D				
Round	1	2	3	4	5	1	2	3	4	5
Responses: F/F	46	45	35	43	41	33	40	28	34	40
Tel.	13	9	14	11	7	16	5	13	7	6
Total	59	54	49	54	48	49	45	41	41	46
Non-Responses:										
Unlisted	26	26	33	25	28	36	39	43	41	39
Unreached	3	6	4	8	10	3	6	4	6	6
No English	5	5	5	4	4	4	2	3	3	3
Other			1		1		1		3	
Refusal	7	9	9	9	9	9	9	8	6	6

ALL NEIGHBORHOODS						
Round	1	2	3	4	5	Σ/N
Responses: F/F	42	46	36	42	44	42
Tel.	16	9	17	11	8	13
Total	58	55	53	53	52	55
Non-Responses						
Unlisted	26	27	32	28	28	28
Unreached	2	6	4	6	8	5
No English	3	2	3	2	2	3
Other	1	1		1	1	1
Refusal	9	9	8	9	9	9

TABLE B-2

MAJOR NEIGHBORHOOD ENVIRONMENTAL PROBLEM

Neighborhood	A					B				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	77	60	58	58	71	59	68	70	69	66
MAJOR ENVIRONMENTAL PROBLEM										
Aircraft	0.72	0.65	0.61	0.54	0.68	0.11	0.41	0.51	0.56	0.50
Air Quality	0.15	0.15	0.12	0.10	0.09	0.45	0.32	0.09	0.16	0.24
Other	0.07	0.09	0.12	0.16	0.08	0.15	0.14	0.19	0.16	0.14
DK	0.04	0.09	0.09	0.17	0.13	0.09	0.10	0.19	0.08	0.11
NA	0.02	0.02	0.05	0.03	0.02	0.20	0.03	0.03	0.05	0.01
Neighborhood	C					D				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	65	57	59	56	62	61	63	66	64	57
MAJOR ENVIRONMENTAL PROBLEM										
Aircraft	0.50	0.44	0.50	0.35	0.48	0.20	0.26	0.44	0.46	0.38
Air Quality	0.19	0.25	0.19	0.10	0.20	0.39	0.41	0.19	0.23	0.24
Other	0.18	0.17	0.18	0.19	0.14	0.20	0.19	0.22	0.16	0.22
DK	0.06	0.11	0.08	0.31	0.16	0.07	0.10	0.12	0.07	0.11
NA	0.06	0.04	0.05	0.05	0.01	0.14	0.04	0.04	0.08	0.05

TABLE B-3

SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

Neighborhood	A					B				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	77	60	58	58	71	59	68	70	69	66
TRAFFIC OVER THE PAST WEEK										
NAA	0.50	0.58	0.57	0.52	0.54	0.48	0.60	0.47	0.53	0.51
SLI	0.23	0.16	0.20	0.25	0.18	0.18	0.12	0.22	0.20	0.22
MOD	0.17	0.15	0.16	0.16	0.18	0.18	0.15	0.17	0.15	0.13
VERY	0.05	0.03	0.03	0.04	0.04	0.11	0.05	0.07	0.06	0.06
EXT	0.04	0.06	0.03	0.02	0.04	0.05	0.07	0.04	0.04	0.07
UNK	0.01	0.02	0.01	0.01	0.02		0.01	0.06	0.02	0.01
*HIGHLY	0.09	0.09	0.06	0.06	0.08	0.16	0.12	0.11	0.10	0.13

Neighborhood	C					D				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	65	57	59	56	62	61	63	66	64	57
TRAFFIC OVER THE PAST WEEK										
NAA	0.41	0.54	0.52	0.51	0.49	0.49	0.48	0.54	0.56	0.49
SLI	0.22	0.21	0.23	0.20	0.24	0.15	0.22	0.19	0.17	0.19
MOD	0.21	0.12	0.18	0.20	0.19	0.22	0.17	0.14	0.17	0.17
VERY	0.07	0.06	0.05	0.06	0.05	0.08	0.08	0.04	0.06	0.08
EXT	0.06	0.06	0.02	0.02	0.02	0.04	0.05	0.05	0.02	0.04
UNK	0.03	0.01		0.01	0.01	0.02		0.04	0.02	0.02
*HIGHLY	0.13	0.12	0.07	0.08	0.07	0.12	0.13	0.09	0.08	0.12

*Highly = Very + Extremely.

TABLE B-4

SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

Neighborhood			A					B		
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	77	60	58	58	71	59	68	70	69	66
AIRCRAFT OVER THE PAST WEEK										
NAA	0.05	0.40	0.38	0.40	0.14	0.46	0.09	0.06	0.06	0.20
SLI	0.06	0.22	0.25	0.25	0.13	0.26	0.10	0.10	0.13	0.22
MOD	0.13	0.14	0.17	0.17	0.17	0.12	0.08	0.15	0.11	0.15
VERY	0.16	0.08	0.08	0.07	0.23	0.08	0.18	0.19	0.21	0.17
EXT	0.58	0.14	0.10	0.09	0.32	0.08	0.54	0.49	0.48	0.25
UNK	0.02	0.02	0.02	0.02	0.01		0.01	0.01	0.01	0.01
*HIGHLY	0.74	0.22	0.18	0.16	0.55	0.16	0.72	0.68	0.69	0.42

Neighborhood			C					D		
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	65	57	59	56	62	61	63	66	64	57
AIRCRAFT OVER THE PAST WEEK										
NAA	0.03	0.15	0.20	0.26	0.15	0.22	0.13	0.10	0.10	0.31
SLI	0.08	0.17	0.22	0.30	0.15	0.10	0.18	0.13	0.20	0.21
MOD	0.09	0.18	0.26	0.18	0.22	0.19	0.21	0.20	0.18	0.21
VERY	0.21	0.17	0.18	0.14	0.22	0.19	0.17	0.15	0.21	0.08
EXT	0.56	0.31	0.14	0.09	0.25	0.28	0.30	0.40	0.30	0.17
UNK	0.03	0.02		0.03	0.01	0.02	0.01	0.02	0.01	0.02
*HIGHLY	0.77	0.48	0.32	0.23	0.47	0.47	0.47	0.55	0.51	0.25

*Highly = Very + Extremely.

TABLE B-5

SUMMARY OF ANNOYANCE AND NOISE DATA FOR FIVE ROUNDS

Neighborhood	A					B				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	77	60	58	58	71	59	68	70	69	66
AIRCRAFT OVER THE PAST YEAR										
NAA	0.05	0.10	0.08	0.07	0.11	0.30	0.28	0.20	0.17	0.10
SLI	0.06	0.10	0.07	0.06	0.06	0.28	0.32	0.26	0.24	0.19
MOD	0.14	0.07	0.14	0.12	0.14	0.16	0.23	0.30	0.26	0.18
VERY	0.19	0.17	0.22	0.15	0.24	0.07	0.05	0.09	0.13	0.19
EXT	0.54	0.54	0.46	0.56	0.42	0.09	0.05	0.12	0.15	0.28
UNK	0.02	0.02	0.03	0.04	0.03	0.10	0.07	0.03	0.05	0.05
*HIGHLY	0.73	0.71	0.68	0.71	0.66	0.16	0.10	0.21	0.28	0.47

Neighborhood	C					D				
Round	1	2	3	4	5	1	2	3	4	5
L_{dn}	65	57	59	56	62	61	63	66	64	57
AIRCRAFT OVER THE PAST YEAR										
NAA	0.04	0.07	0.07	0.08	0.08	0.20	0.14	0.12	0.09	0.18
SLI	0.07	0.07	0.07	0.09	0.10	0.16	0.20	0.18	0.15	0.22
MOD	0.14	0.12	0.15	0.17	0.16	0.22	0.26	0.24	0.24	0.25
VERY	0.21	0.20	0.20	0.18	0.25	0.16	0.17	0.14	0.22	0.11
EXT	0.49	0.51	0.46	0.43	0.37	0.17	0.14	0.23	0.20	0.17
UNK	0.05	0.03	0.05	0.05	0.04	0.09	0.09	0.09	0.10	0.06
*HIGHLY	0.70	0.71	0.66	0.61	0.62	0.33	0.31	0.37	0.42	0.28

*Highly = Very + Extremely.

TABLE B-6
NUMBER OF SMALL AIRPLANES AS ANNOYING
AS ONE AIR CARRIER AIRCRAFT

(RAW DATA)

Neighborhood	A	B	C	D	A
L_{dn}	71	66	2	57	
Not Annoyed by Either	14	1	2	2	19
Small and Large Aircraft Equally Annoying	28	4	10	10	52
Small Aircraft More Annoying	23	11	5	17	56
Not Annoyed by Small	16	10	14	5	45
DK	53	53	59	70	235
NA	16	40	37	31	124
Refused	2	1	1	1	5
					536
# Remaining	134	120	80	77	411
$\overline{X}$	44	65	15	35	43
Median	10	10	6	10	10
Mode	10	10	10	10	10

(% DATA)

Neighborhood	A	B	C	D	A
L_{dn}	71	66	62	57	
Not Annoyed by Either	0.05		0.01	0.01	0.02
Equally Annoying	0.10	0.02	0.05	0.05	0.05
Small More Annoying	0.08	0.05	0.02	0.08	0.06
Not Annoyed by Small	0.06	0.04	0.07	0.02	0.05
DK	0.19	0.22	0.28	0.33	0.25
NA	0.06	0.17	0.18	0.15	0.12
Refused	0.01				0.01
	0.55	0.50	0.61	0.64	0.57
					0.43

able to make a judgment

TABLE B-7
SUMMARY OF ANNOYANCE AND NOISE DATA FOR ROUND 5

Neighborhood	A	B	C	D
L_{dn}	71	66	62	57
Concern of People Who Run Airports and Airplanes				
NAA	0.54	0.40	0.50	0.31
SLI	0.18	0.17	0.19	0.34
MOD	0.12	0.20	0.14	0.17
VERY	0.07	0.11	0.08	0.06
EXT	0.01	0.03		0.02
UNK	0.08	0.09	0.09	0.20
*HIGHLY	0.08	0.14	0.08	0.08

*Highly = Very + Extremely.

TABLE B-8

SUMMARY OF AUXILIARY INFORMATION FOR FIVE ROUNDS

Neighborhood	A		B		C		D		ALL	
	N	%	N	%	N	%	N	%	N	%
Type of Interview										
F/F	1292	76	760	75	881	80	963	79	3896	77
Tel.	411	24	255	25	218	20	261	21	1145	23
	1703		1015		1099		1224		5041	
Sex:										
Female	943	55	578	57	606	55	508	42	2635	52
Male	736	43	428	42	481	44	694	57	2339	46
Unknown	24	1	9	1	12	1	22	2	67	1
Age:										
<30	391	23	279	27	322	29	511	42	1503	30
30-50	785	46	424	42	445	40	479	39	2133	42
>50	463	27	235	23	290	26	184	15	1172	23
Unknown	64	4	77	8	42	4	50	4	233	5

APPENDIX C

APPLICATION OF THE PSYCHOPHYSICAL THEORY OF SIGNAL DETECTABILITY TO ANALYSES OF CHANGES IN COMMUNITY RESPONSE TO NOISE EXPOSURE

I. BACKGROUND INFORMATION

The psychophysical theory of signal detectability (Green and Swets, 1966) provides another perspective on the data collected in this study. The theory employs plots known as Receiver Operating Characteristics (ROC curves) to summarize the entire range of decision making performance possible for a decision maker of fixed sensitivity. The types of problems most often addressed within this theoretical framework involve perceptual decision making under conditions of uncertainty and risk. The area of uncertainty concerns the presence or absence of some physical condition, while the risk is associated with real-world decision outcomes.

The ROC curve distinguishes the fundamental sensitivity of the decision maker to physical conditions from the obscuring influences on his decisions of the costs and payoffs of the outcomes of his decisions ("response bias"). The ROC curve makes explicit the relationship between two forms of "correct" and "incorrect" decisions: decisions that some condition is present when in fact it actually is present ("hits"); and decisions that some condition is present when in fact it is not ("false alarms").

The relationship is curvilinear on linear axes, but linear on normal probability axes. The shape of the relationship is a consequence of the manner in which the areas under each of two distributions to the left and right of a fixed decision criterion vary as the criterion is shifted to take

account of the costs and payoffs of decision outcomes
(see below). The decision making process itself is quite
similar to that of a parametric statistical inferential
test, such as a t-test.

The theoretical framework of the Theory of Signal Detect-
ability is sufficiently general that it readily accommodates
the present problem of assessing the effects of changes in
aircraft noise exposure on changes in the prevalence of
annoyance in communities. In this application, the
"decision maker" is not an individual, but a group of
people; the "decision" concerns which degree of annoyance
to report to an interviewer; and the "sensitivity" involved
is that summarized by the dosage-response relationship
(transfer function) between noise exposure and annoyance.

Application of the model of decision making under conditions
of uncertainty and risk may be understood by considering
the exemplary set of personal decision criteria for a
resident of an airport neighborhood seen in Figure C-1.
The shape of the exposure distribution is assumed for
reasons of convenience to be Gaussian, although this
assumption is clearly not critical.

When an interviewer asks a respondent "How annoyed are you
by aircraft noise... ", the respondent is assumed to decide
how to describe his annoyance by evaluating exposure with
regard to these personal decision criteria, as illustrated
in Figure C-1. Proportions of the community expressing
common degrees of annoyance may therefore be regarded as
composed of people whose exposure or criteria for judging
it correspond.

Suppose now that the exposure distribution changes (shifts
to the left or right on the abscissa of Figure C-1) due to

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Decision Rule:
Describe Exposure Exceeding Criterion As:

FIGURE C-1. EXAMPLE OF HYPOTHETICAL INTERNAL CRITERIA FOR SELF REPORTED ANNOYANCE TO AIRCRAFT NOISE.

* Hypothetical values based on data of Fidell and Teffeteller, 1981

decreases or increases in numbers of aircraft overflights.
If the personal decision criteria remain constant, dif-
ferent proportions of the community will express varying
degrees of annoyance, as shown in Figure C-2. For example,
more people will describe themselves as "very" or "extremely"
annoyed and fewer people will describe themselves as "not
at all" or "slightly annoyed", as the distribution of
aircraft noise exposure shifts to the right.

A metric known as d', based on the distance between the
means of the two distributions (normalized by dividing the
standard deviation of the leftmost distribution), yields a
single parameter that can be used to characterize the entire
ROC curve.

Decision Rule:

Describe Exposure Exceeding Criterion As:
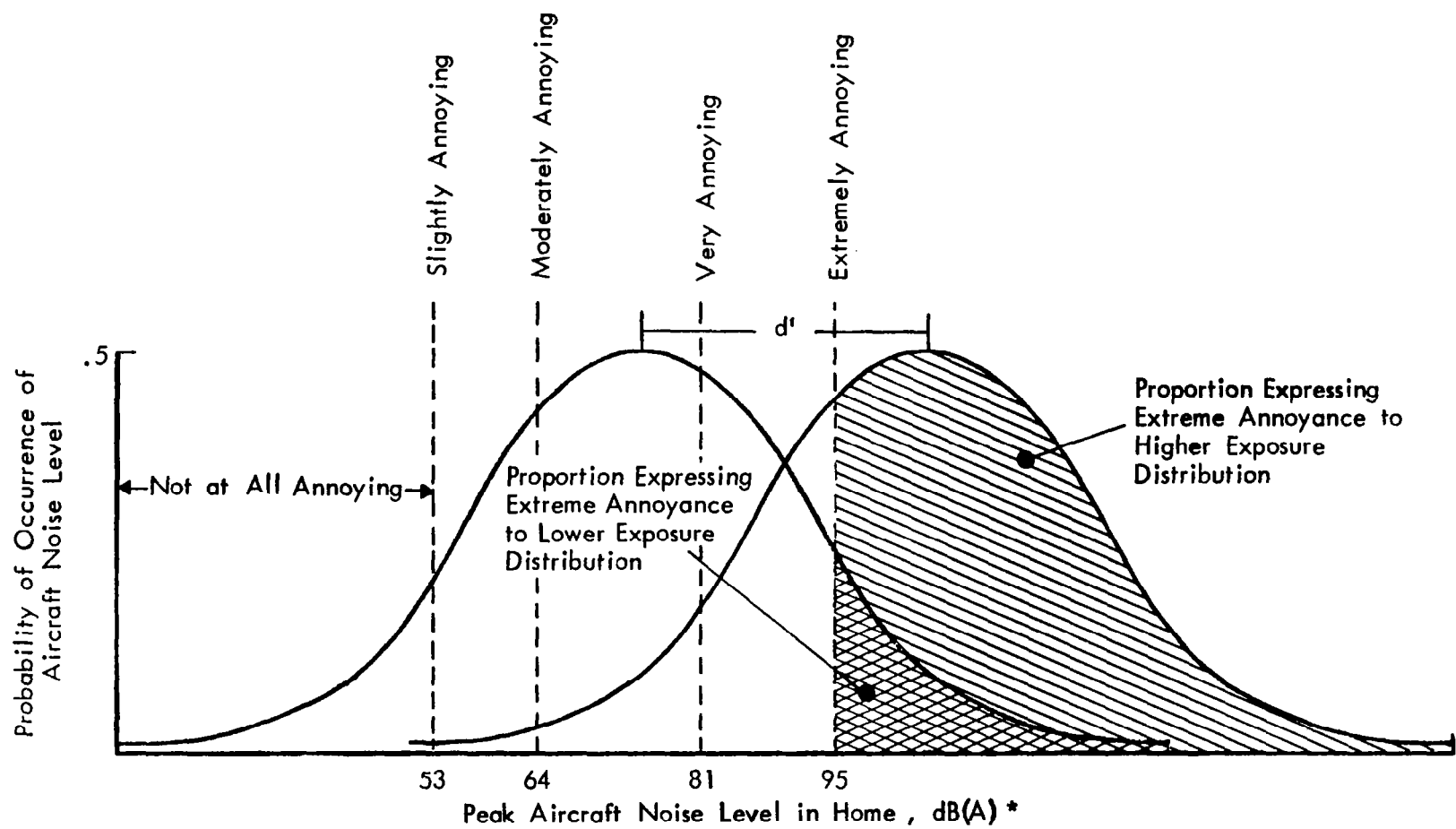
* Hypothetical values based on data of Fidell and Teffeteller, 1981

FIGURE C-2. ILLUSTRATION OF DIFFERENCE IN PROPORTIONS OF PEOPLE REPORTING EXTREME ANNOYANCE AS A FUNCTION OF CHANGE IN EXPOSURE RATHER THAN CHANGE IN CRITERIA FOR ANNOYANCE.

II. APPLICATION TO CURRENT DATA

A. Invariance of Annoyance Due to Traffic Noise

Distributions of respondents reporting varying degrees of
annoyance to the local traffic noise during the preceding
week may be examined using the techniques outlined above.
Figure C-3 (plotted from the data in Table B-3) shows the
cumulative proportions of respondents in each category
of annoyance observed in the first round of interviews
versus the same figures averaged over the next four rounds
of interviews. In this presentation, points lying along
the positive diagonal represent a lack of discriminable
difference between the variables plotted on the abscissa
and the ordinate.

The proximity of the points of Figure C-3 to the positive
diagonal therefore illustrate the lack of change in the
respondent's reaction to traffic noise exposure throughout
the course of this study. Thus, distributions of respondents
reporting varying degrees of annoyance due to local street
traffic noise during the preceding week were stable and
consistent over rounds of interviewing. This finding is
hardly surprising, considering the negligible changes in
ambient noise levels (see Table 1) in the weeks preceding
each round of interviews.

B. Sensitivity to Changes in Aircraft Noise Exposure

The dependence of annoyance upon aircraft noise exposure
is demonstrated in Figure C-4, in which responses to
Question 3 are plotted in the fashion described for
Figure C-3. The abscissa quantifies normalized cumu-
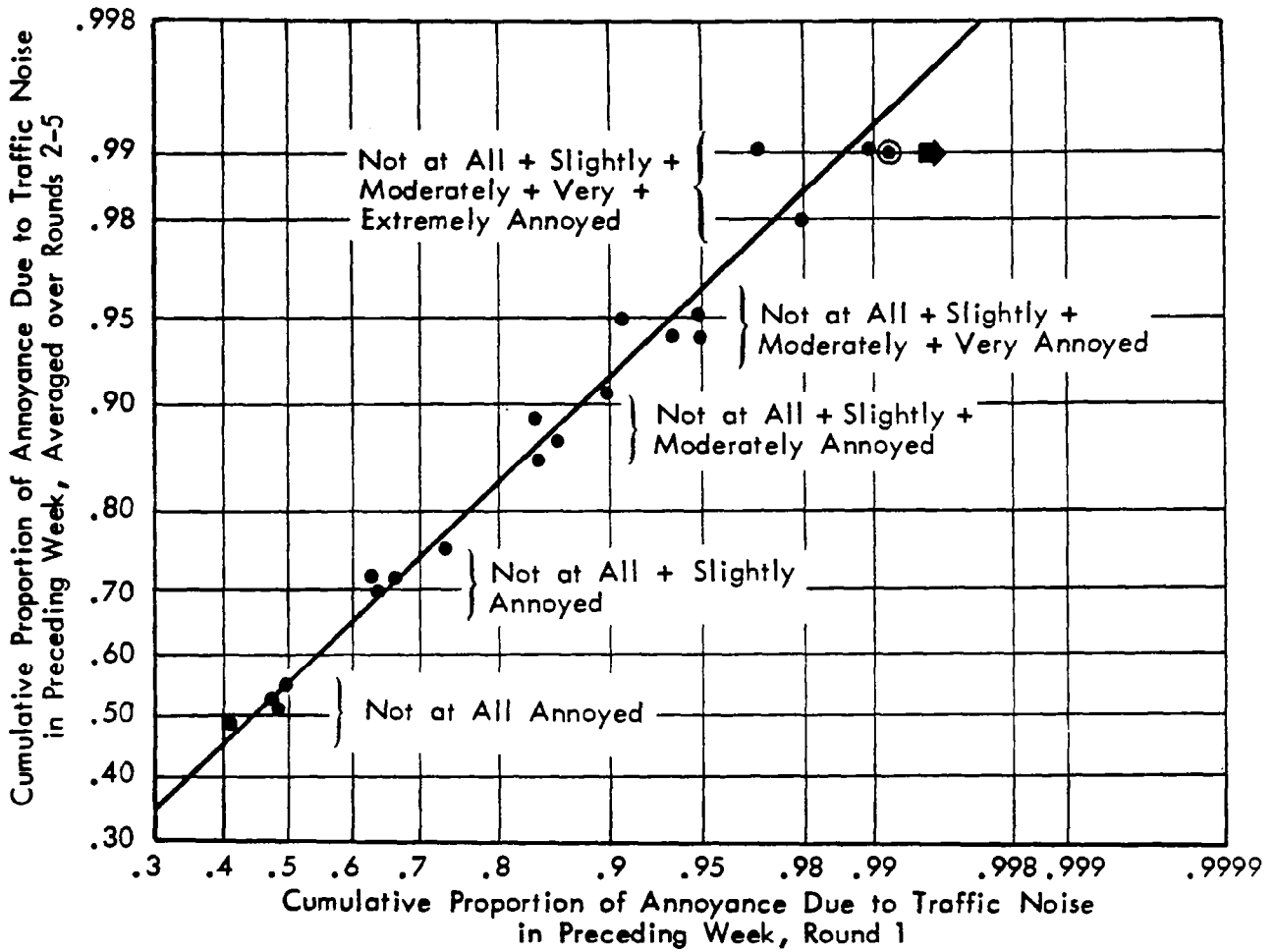
FIGURE C-3. COMPARISON OF DISTRIBUTIONS OF ANNOYANCE
TO TRAFFIC NOISE BETWEEN INTERVIEW ROUNDS.
EACH POINT REPRESENTS ONE NEIGHBORHOOD.
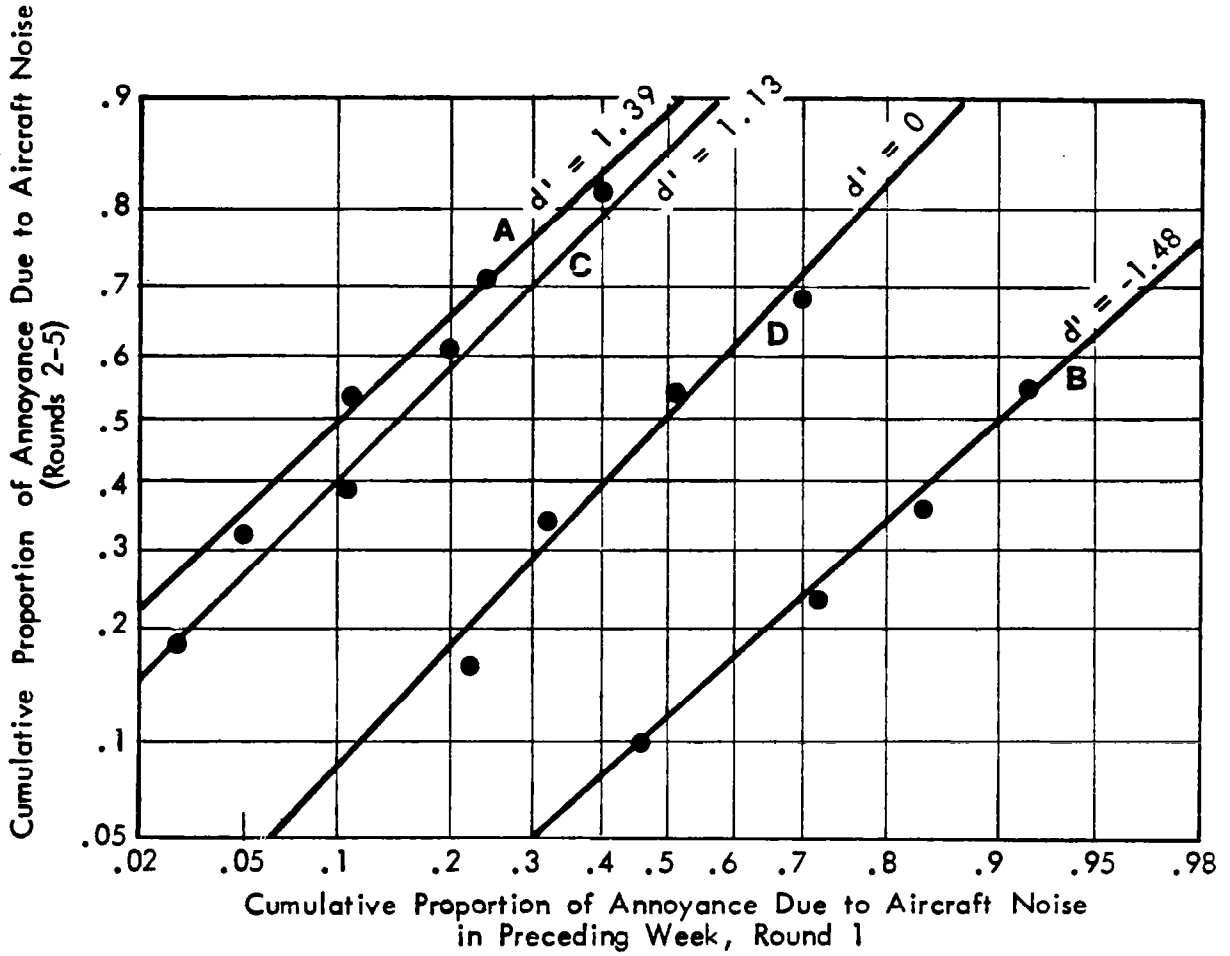
FIGURE C-4. COMPARISON OF DISTRIBUTIONS OF ANNOYANCE
TO AIRCRAFT NOISE (OVER PAST WEEK) AMONG
INTERVIEW ROUNDS.

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lative proportions of respondents expressing varying
degrees of annoyance with aircraft noise in the week
preceding the first round of interviews. The ordinate
quantifies the distribution of annoyance averaged over
the following four rounds of interviews.

Several aspects of the relationships revealed in Figure
C-4 are noteworthy. First, notice that data for the
different neighborhoods are regularly displaced from
the positive diagonal by an amount related to the change
in exposure. The points for Neighborhoods A and B which
underwent the greatest changes in aircraft noise exposure
are displaced farthest from the positive diagonal.

The data points for Neighborhood C, which experienced an
intermediate change in exposure, are proportionally closer
to the positive diagonal. The data points for Neighborhood
D, which experienced only slight increases in exposure in
rounds 2-4, and a small decrease in round 5, are indis-
tinguishably close to the positive diagonal, as were
the annoyance data for street traffic noise in all
neighborhoods in Figure C-3.

The values of d' shown in Figure C-4 are indices of how
detectable the changes in noise environment were to the
respondents in each neighborhood. Given that the variance
of annoyance responses (across categories) did not change
appreciably with changes in exposure levels (evidenced
by the alignment of data points nominally parallel to
a unit slope diagonal), d' is the number of standard
deviations the mean value of the distribution shifted
as a result of the exposure change.

In Figure C-4, the position of the data points for Neighborhood B, below the positive diagonal, results from an observed increase in annoyance from the first round to successive rounds of interviews due to an increase in aircraft noise exposure. The positions of the data points for Neighborhood A and C, above the positive diagonal, result from an observed decrease in annoyance from the first round to successive rounds of interviews due to a decrease in aircraft noise exposure.

Pairs of data points plotted as in Figures C-3 and C-4 lie along a straight line ROC curve (on normal probability axes) only if the underlying assumptions of the signal detection analysis are valid. The straight line ROC curves so plotted will only be parallel to the positive diagonal if the decision criteria remain in the same relative positions in the different exposure conditions. The interested reader is encouraged to consult Green and Swets (1966) for a fuller and more formal background in these types of analyses.

The major implications of the excellent account of the present data given by a detection-theoretical analysis is that changes in community annoyance with changes in aircraft noise exposure are orderly and lawfully governed, and that considerable insight into the processes governing such changes in reaction may be understood in systematic detail.

APPENDIX D

DISTRIBUTIONS OF AIRCRAFT NOISE EXPOSURE

A more detailed picture of the noise exposure at the
various measurement sites is indicated by the distribution
of noise levels over some time period. Therefore, dis-
tributions are presented of maximum A-weighted sound
levels from individual aircraft noise intrusions compiled
from the aircraft noise monitor data acquired in each
neighborhood. Figure D-1 through D-12 present a com-
pilation over a one-week period immediately prior to an
interview round. The data presented in these figures have
been screened on the basis of event duration (top 10 dB).
Noise events of unreasonably short or long duration (less
than 5 seconds or greater than 45 seconds), and thus
unlikely to have arisen from aircraft flyovers, are
excluded.

The distributions shown are not exhaustive (i.e., they are
not shown for every neighborhood and every interview round).
They do, however, present a representative picture of the
aircraft noise climate in each neighborhood over the course
of the study.
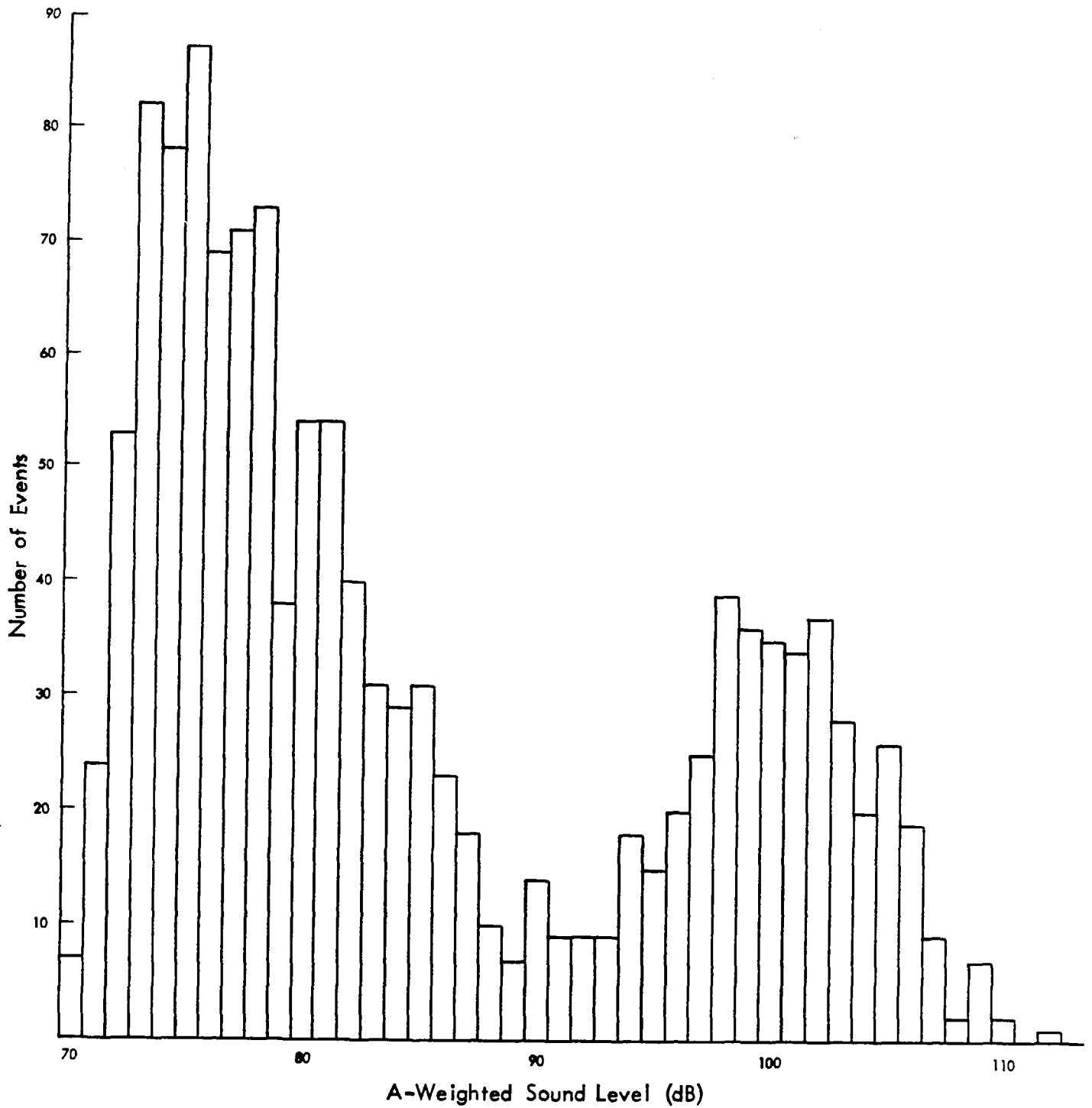
FIGURE D-1.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD A
(Week prior to round 1).
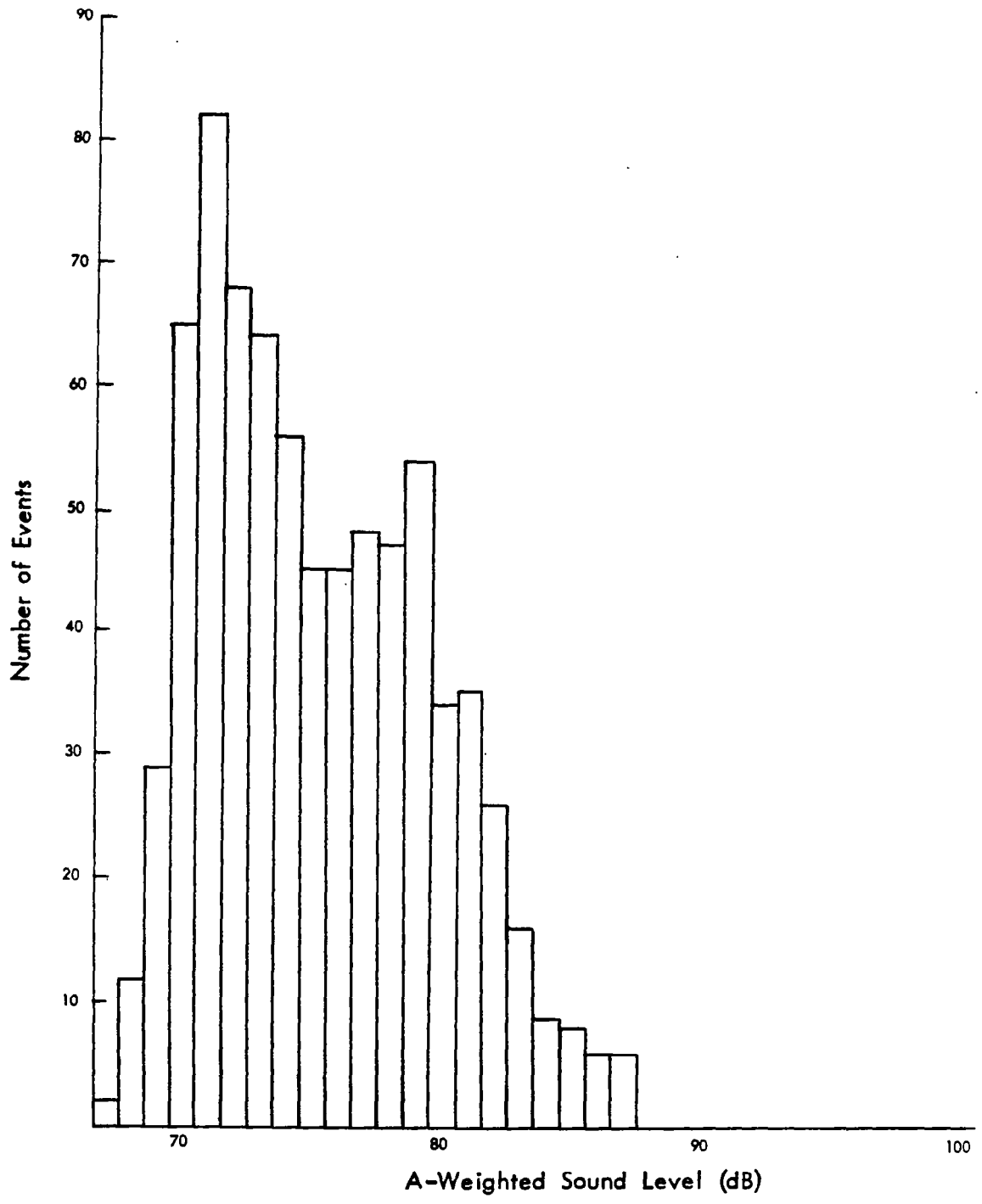
FIGURE D-2. DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD A
(Week prior to round 4).
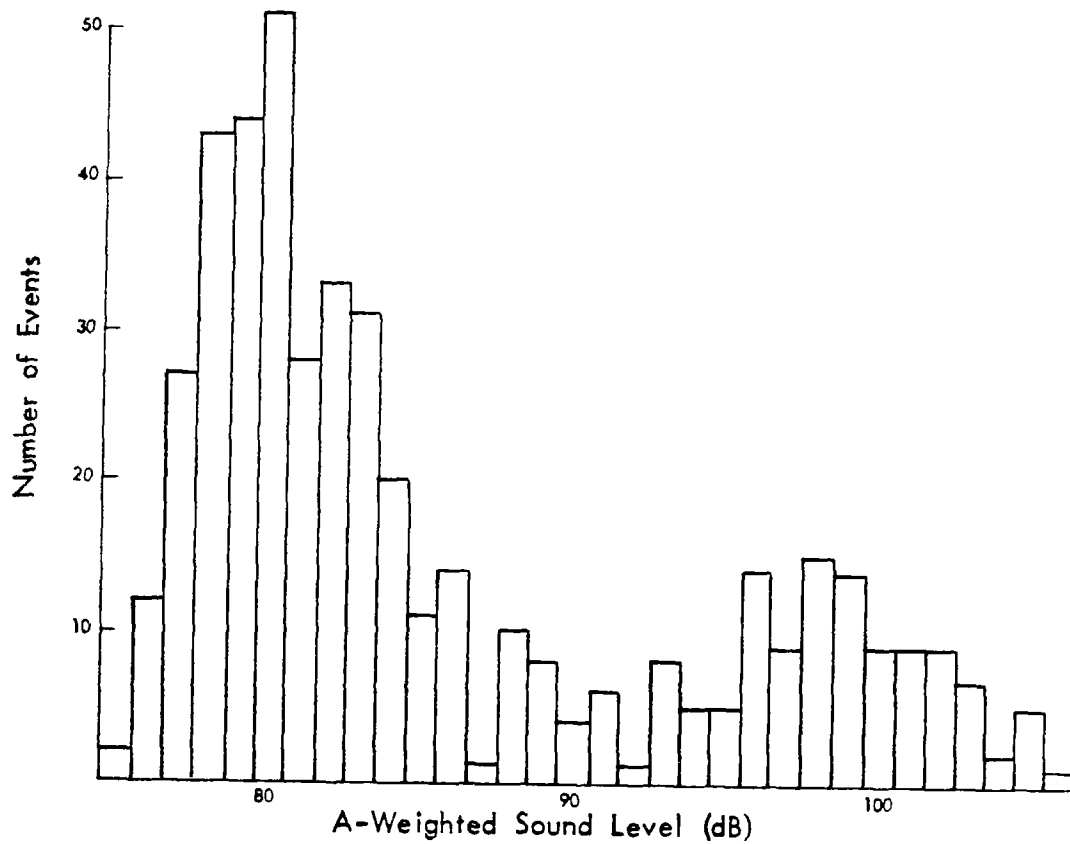
FIGURE D-3.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD A
(Week prior to round 5).
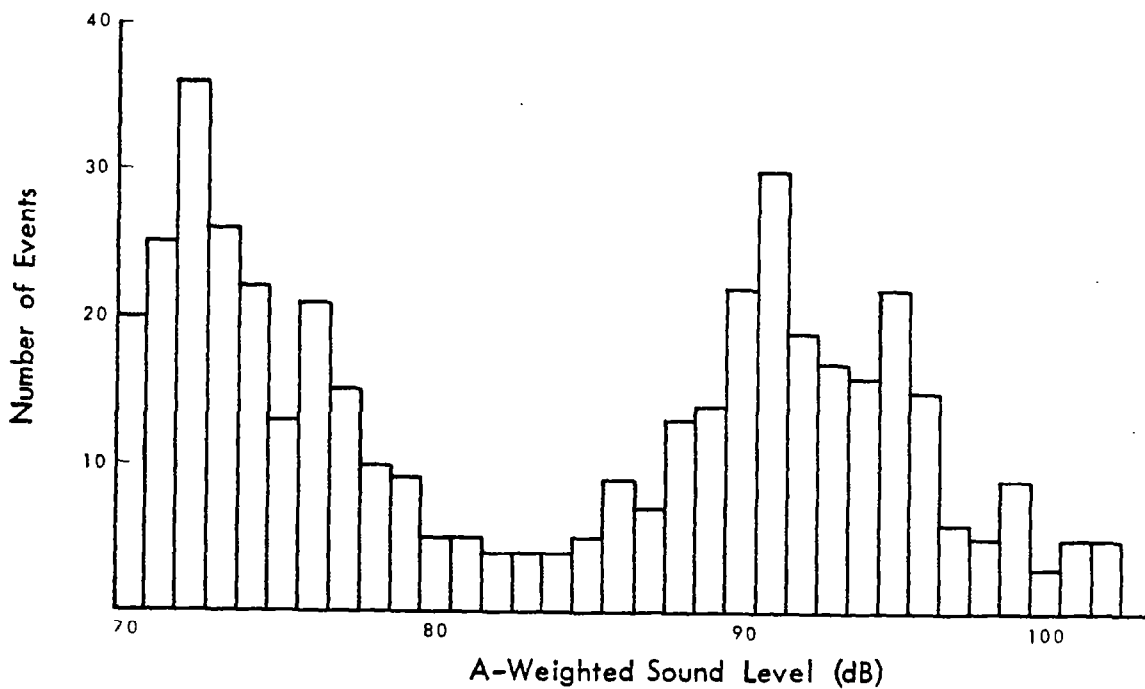
FIGURE D-4. DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD B
(Week prior to round 2).
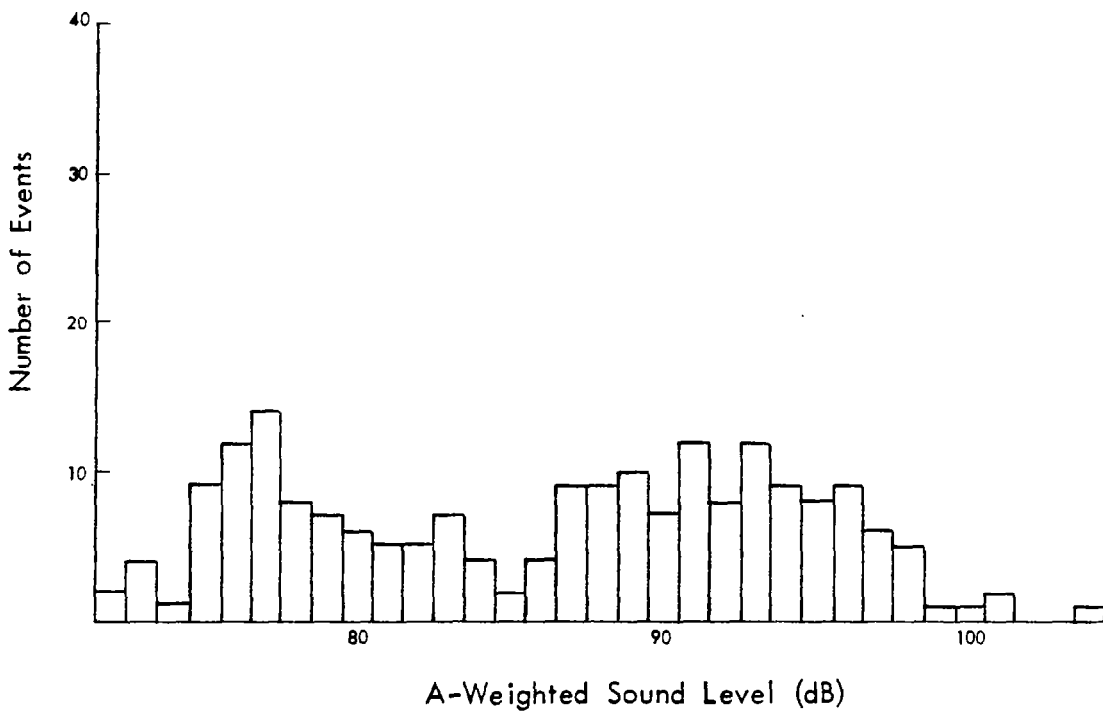
FIGURE D-5.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD B
(Week prior to round 5).
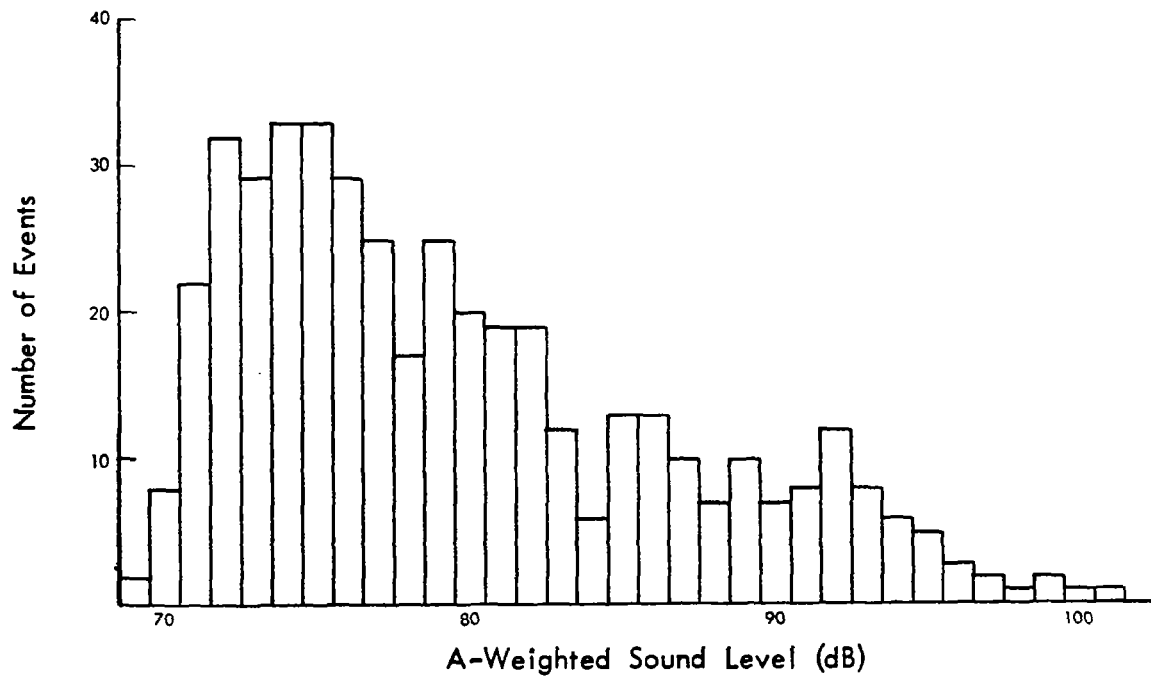
FIGURE D-6. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND LEVELS FOR NEIGHBORHOOD C (Week prior to round 1).
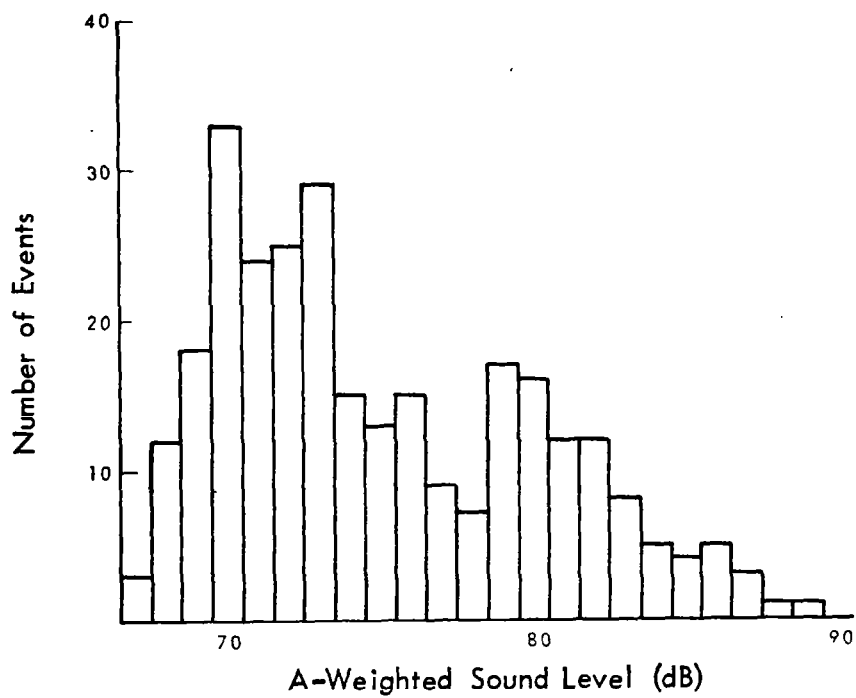
FIGURE D-7.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD C
(Week prior to round 2).
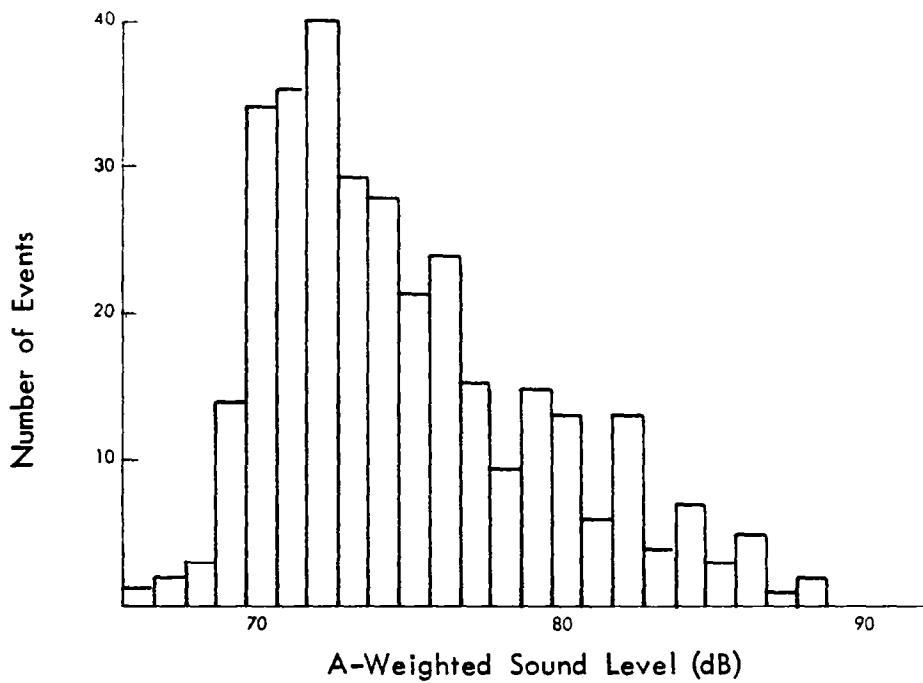
FIGURE D-8.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD C
(Week prior to round 4).
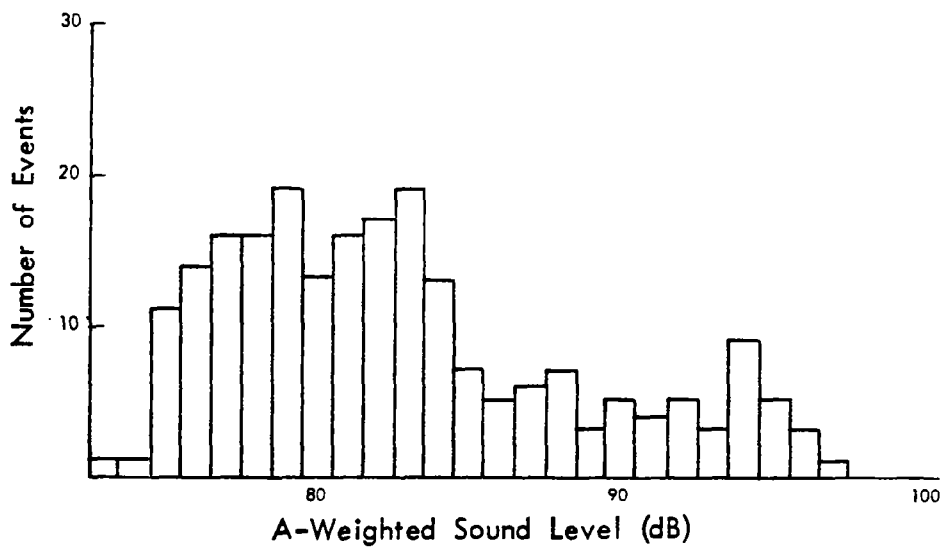
FIGURE D-9.   DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD C
(Week prior to round 5).

90
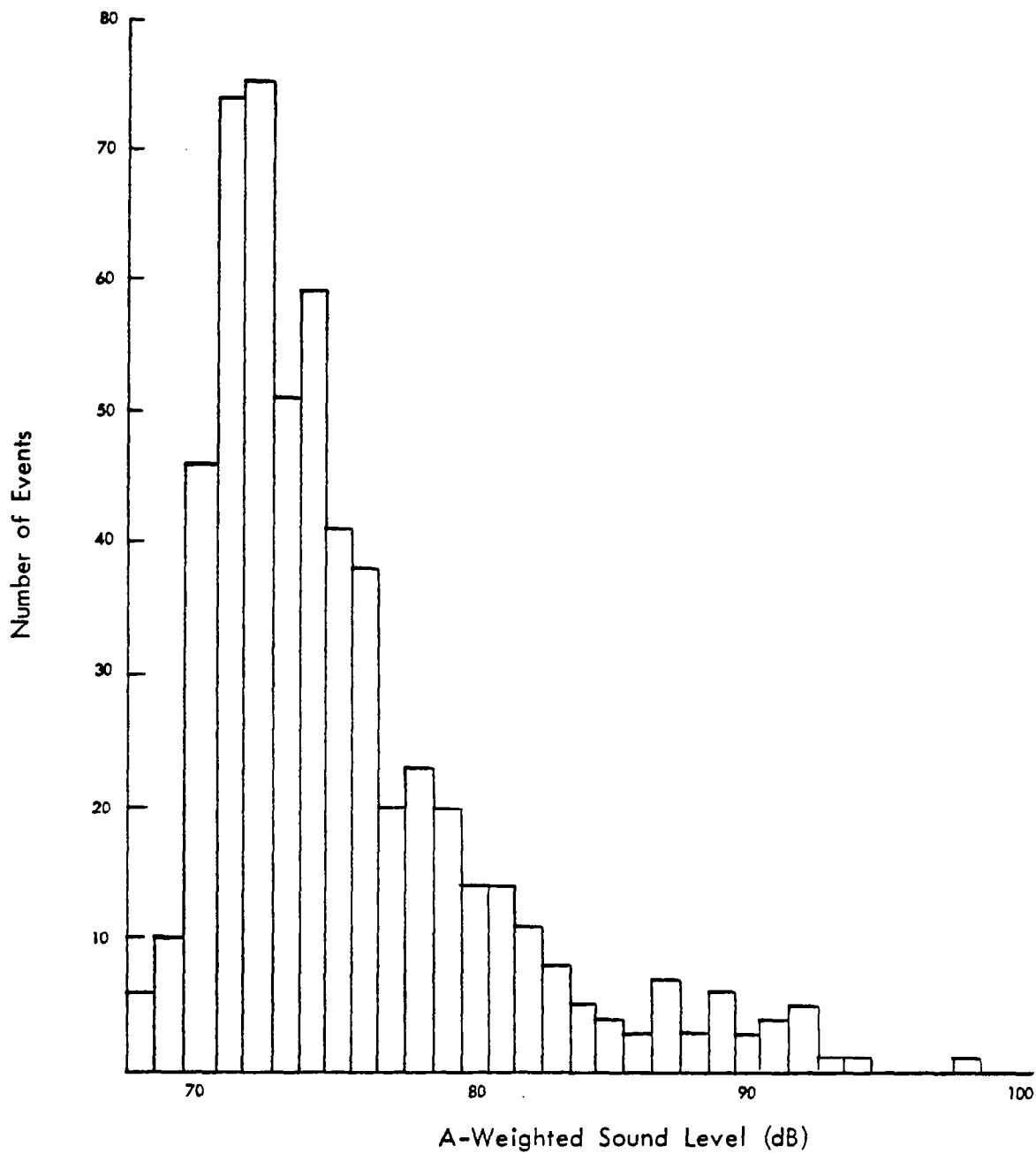
FIGURE D-10. DISTRIBUTION OF MAXIMUM A-WEIGHTED SOUND
LEVELS FOR NEIGHBORHOOD D (Week prior to round 2).
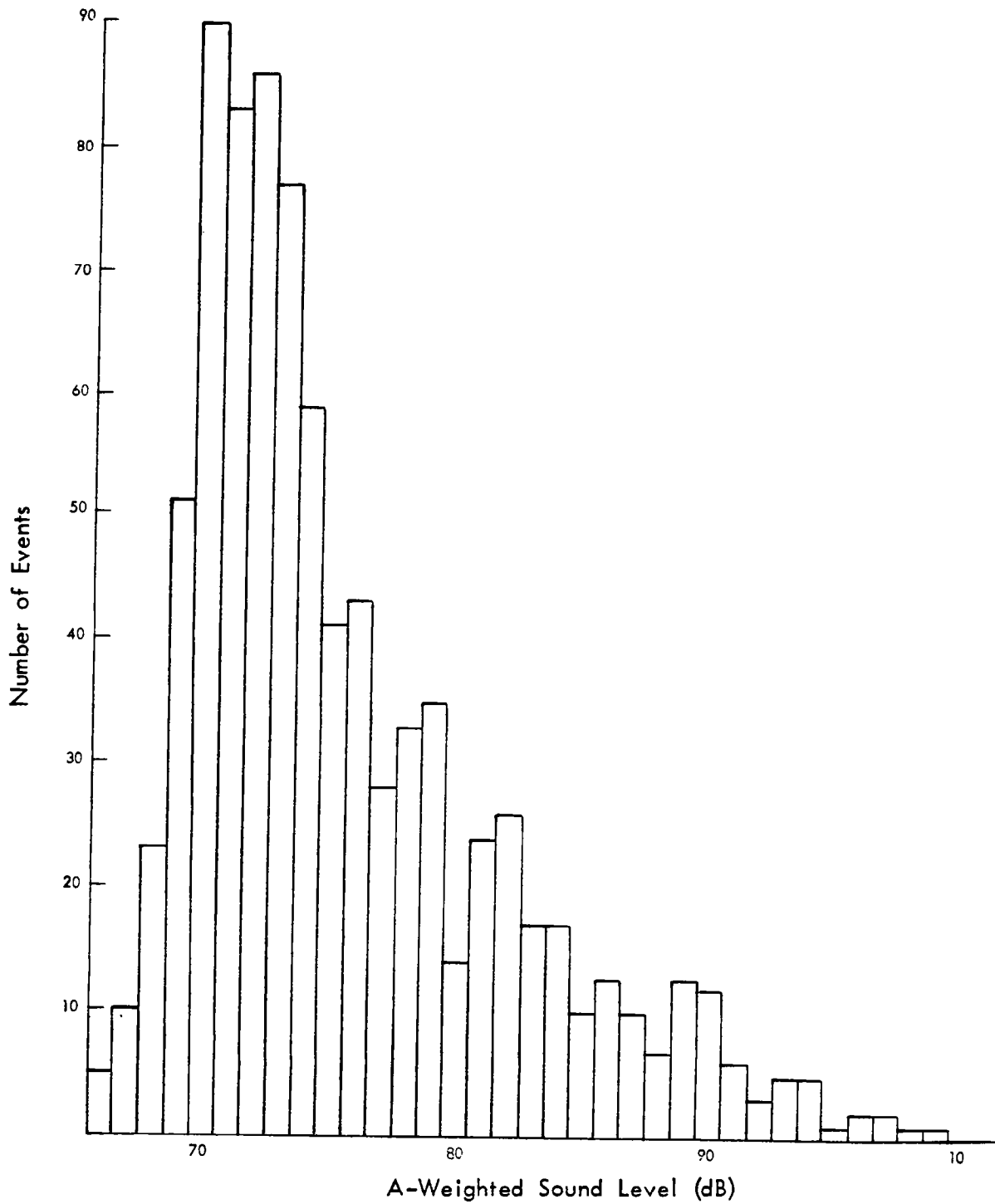
FIGURE D-11. DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD D
(Week prior to round 4).
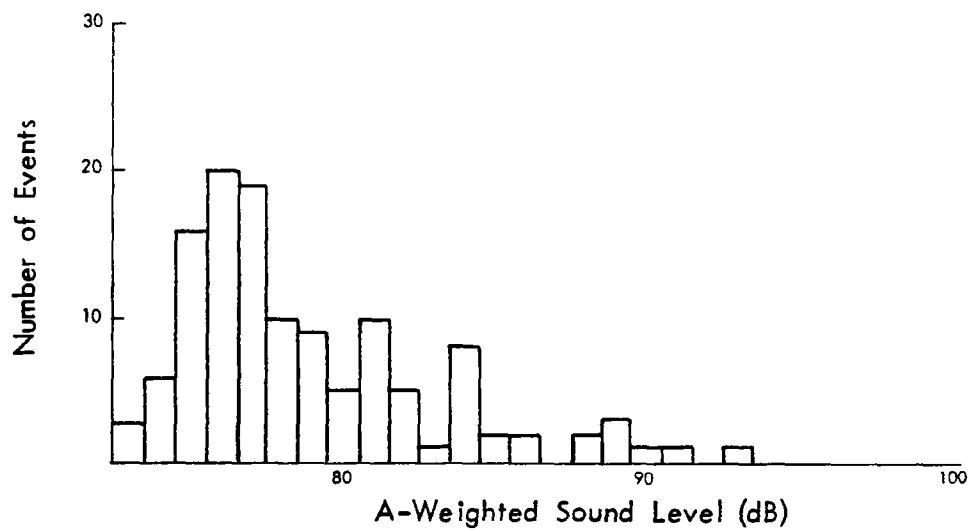
FIGURE D-12. DISTRIBUTION OF MAXIMUM A-WEIGHTED
SOUND LEVELS FOR NEIGHBORHOOD D
(Week prior to round 5).

APPENDIX E

SPATIAL SOUND EXPOSURE DIFFERENTIALS IN NEIGHBORHOOD A

This appendix describes simultaneous sound level monitoring at five sites in Neighborhood A undertaken to quantify the means and extremes of the daily noise exposure range. Neighborhood A is immediately south of the airport, approximately 2 miles from brake release. The predominant noise source is jet aircraft departures on runway 15. Maximum A-weighted sound levels from departing jet aircraft are on the order of 95 to 105 dBA.

Figure E-1 shows the interview area (bounded by the heavy broken line), computer generated noise contours, and the location of the noise monitors. Monitor site 0001 is a remote monitor station (RMS) of the permanent Burbank noise monitor system with a microphone atop a 6-meter high pole along a lightly traveled residential street. Site 0001 is actually outside the interview neighborhood boundary, but provides useful information for establishing gradients. The remaining four sites are in rear yards of single story, single family residences. The microphones at these sites were located atop a 2.4-meter high pole and connected to BBN Model 704 noise monitors described in Appendix A.

Site 2036 is the central site where measurements were acquired in this neighborhood prior to each of the five interview rounds. Site 2141 is typical of the highest noise exposure to be found in the neighborhood, while site 1910 is typical of the lowest. Like site 2036, site 2029 was chosen to be
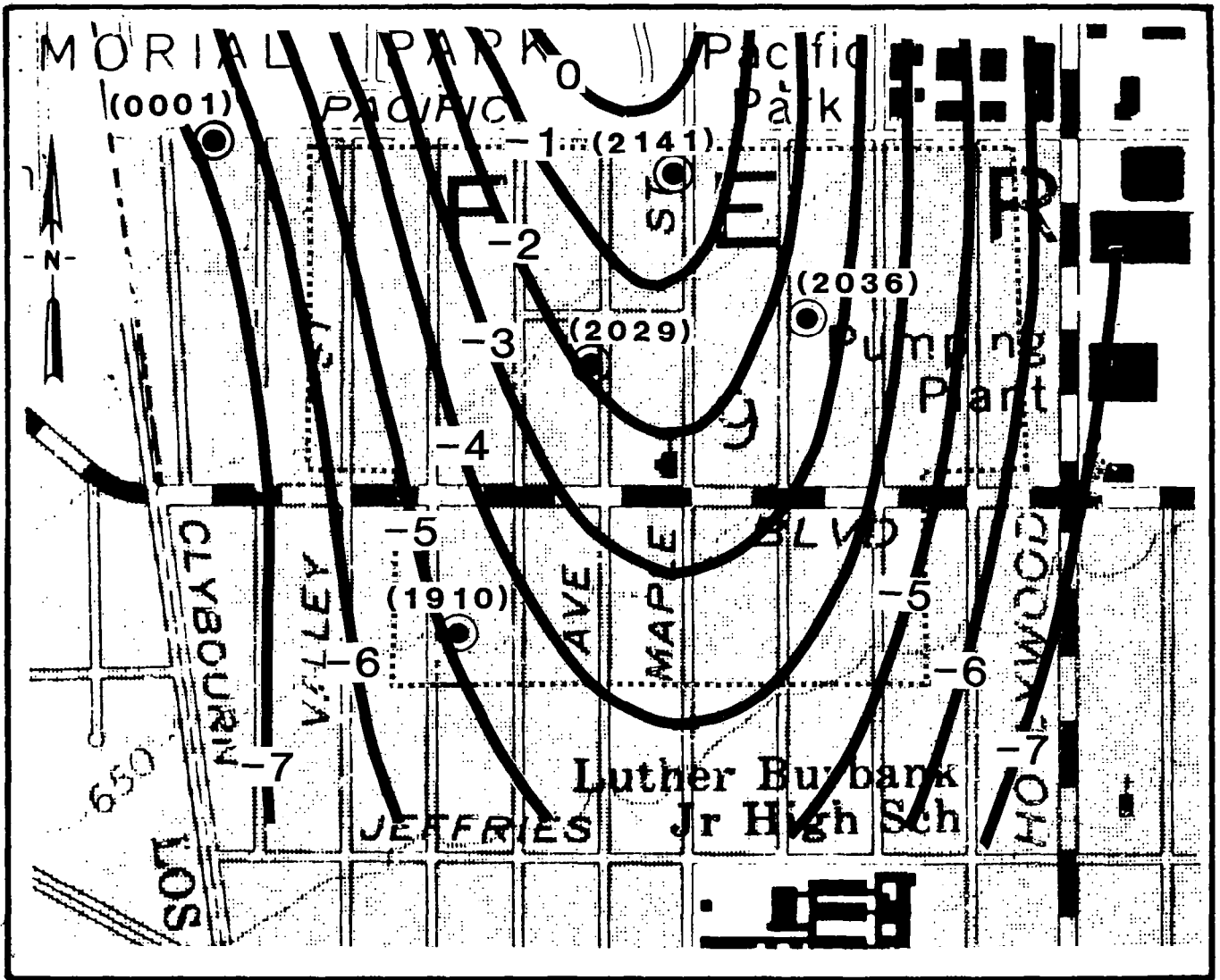
FIGURE E-1.   AUXILIARY NOISE MONITOR SITES -
NEIGHBORHOOD A.

representative of a neighborhood average. This site was
selected by personnel different from those who originally
selected site 2036. Noise monitoring equipment was also
installed and serviced by different personnel. The period
during which these special purpose measurements were made
lasted eight calendar days (12-19 January 1981) following
interview round 5.

All monitors operated in a threshold detecting mode to dis-
tinguish transient noise intrusions from the general background
noise in the community. Only those intrusions whose maximum
sound level exceeded a preset threshold (approximately 68 dB[A])
were recorded and subsequently tabulated by time of day, maxi-
mum A-level, upper 10 dB duration, and SEL (integrated over
the time between threshold crossings). Individual SEL's
were subsequently energy summed to obtain hourly noise levels
(HNL) and Day/Night average levels (L_{dn}).

The choice of microphone locations substantially reduced the
chance that non-aircraft noise intrusions would be recorded
by the noise monitor because ground based noise sources,
attenuated by a row of houses, would only rarely produce
jet aircraft magnitude sound levels at the microphones.
Those non-aircraft intrusions that were recorded were likely
to be of sufficiently low level as to effect computed HNL
and L_{dn} values only negligibly. Nonetheless, noise monitor
records were screened for events of high maximum sound level,
but unusually long or short duration. These events (which
were extremely rare) were then cross checked against the
records of a nearby monitor to see whether or not the
same event occurred there simultaneously. If it did not,
the event was discarded.

Table E-1 shows the measured L_{dn} at the five measurement sites, along with the deviations from the central site (2036). Only a partial day's data was acquired on the 12th and the 19th since these were equipment installation and removal days. Thus, no L_{dn} values are shown for these calendar days. On the 17th a 2:00 am departure of a C-5A controlled the L_{dn} for the whole day. Hence, the measured L_{dn} on this date was atypical: it did not represent an average over many equally contributing events. The remaining five calendar days were more typical of aircraft operations. L_{dn} comparison statistics are computed over these days only.

An energy average L_{dn} over the five calendar days is also shown in Table E-1 for each site, along with the difference in this energy average from that of the central site. Also shown is the arithmetic average and standard deviation of the daily deviations from the central site. The close agreement (less than 0.1 dB) between the energy and arithmetic average is not surprising, considering the small daily variations. The 95% confidence interval for the arithmetic average is also shown as an aid to interpreting inter-site differences, and differences between measured and predicted exposure.

In addition to the L_{dn} analyses, inter-site comparisons were also made at a more microscopic level. Figures E-2 through E-9 show the hourly noise levels measured at each site and the differences between these and the central site levels (labeled DELTA). Data are incomplete for the 12th and the 19th for reasons discussed earlier. The goal of this fine grained analysis was to reduce the effects of non-aircraft intrusions and nighttime anomalies on the inter-site comparisons.

TABLE E-1. DAY NIGHT AVERAGE LEVEL COMPARISONS

BETWEEN MEASUREMENT SITES IN NEIGHBORHOOD A

SITE / DATE	2036	2141	RE: 2036	2029	RE: 2036	1910	RE: 2036	0001	RE: 2036
1-13-81	76.9	78.8	1.9	76.4	-0.5	72.9	-4.0	71.4	-5.5
1-14-81	75.5	78.2	2.7	75.5	0.0	71.9	-3.6	70.0	-5.5
1-15-81	73.7	76.0	2.3	73.6	-0.1	69.9	-3.8	67.9	-5.8
1-16-81	73.7	76.1	2.4	73.5	-0.2	70.3	-3.4	68.4	-5.3
1-17-81*	77.9	77.0		77.0		69.3		71.0	
1-18-81	71.3	73.8	2.5	71.5	0.2	67.8	-3.5	65.6	-5.7
Energy Average	74.62	76.93	2.31	74.43	-0.19	70.90	-3.72	69.09	-5.53
Arithmetic Average			2.36		-0.12		-3.66		-5.56
Arithmetic Std. Dev.			0.30		0.26		0.24		0.20
Arithmetic 95% C.I.			0.27		0.23		0.22		0.17

* Early morning C-5A departure controls L_{dn} for the day.

SITE COMPARISON ANALYSIS

DATE 01-12-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

HOUR	2036 HNL	2036 DELTA	2141 HNL	2141 DELTA	2029 HNL	2029 DELTA	1910 HNL	1910 DELTA	0001 HNL	0001 DELTA
----- NIGHT -----										
00-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
01-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.0	0.0
06-07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
----- DAY -----										
07-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76.0	0.0
08-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.4	0.0
09-10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.0	0.0
10-11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.7	0.0
11-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.3	0.0
12-13	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.5	-3.5*
13-14	80.6	0.0	82.9	2.3*	0.0	0.0	0.0	0.0	76.9	-3.7*
14-15	79.0	0.0	81.3	2.3*	75.6	-3.4*	68.6	-10.4*	72.8	-6.2*
15-16	77.8	0.0	78.4	.6*	79.0	1.2*	76.9	-.9*	72.3	-5.5*
16-17	80.4	0.0	83.0	2.6*	80.1	-.3*	75.8	-4.6*	73.2	-7.2*
17-18	78.9	0.0	81.3	2.4*	78.2	-.7*	73.9	-5.0*	72.0	-6.9*
18-19	70.9	0.0	73.4	2.5*	71.2	.3*	67.3	-3.6*	67.8	-3.1*
----- EVENING -----										
19-20	79.2	0.0	82.9	3.7*	81.1	1.9*	78.3	-.9*	74.3	-4.9*
20-21	50.3	0.0	53.1	0.0	48.7	0.0	44.7	0.0	60.0	0.0
21-22	49.3	0.0	48.1	0.0	0.0	0.0	0.0	0.0	55.8	0.0
----- NIGHT -----										
22-23	58.8	0.0	60.6	1.8*	59.2	.4*	56.5	-2.3*	56.9	-1.9*
23-00	50.9	0.0	56.6	0.0	54.3	0.0	54.9	0.0	53.2	0.0

FIGURE E-2. HOURLY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A,
12 JANUARY 1981.

SITE COMPARISON ANALYSIS

OATE 01-13-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	50.7	0.0	48.7	0.0	45.7	0.0	41.0	0.0	0.0	0.0
01-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-03	47.3	0.0	53.2	0.0	49.2	0.0	50.2	0.0	52.1	0.0
03-04	56.6	0.0	59.5	2.9*	54.3	-2.3	0.0	0.0	0.0	0.0
04-05	33.4	0.0	42.5	0.0	34.2	0.0	0.0	0.0	0.0	0.0
05-06	0.0	0.0	0.0	0.0	35.0	0.0	0.0	0.0	0.0	0.0
06-07	57.1	0.0	58.4	1.3*	55.4	-1.7*	45.1	-12.0	61.5	4.4*
----- DAY -----										
07-08	82.0	0.0	84.3	2.3*	80.5	-1.5*	77.0	-5.0*	77.6	-4.4*
08-09	82.6	0.0	85.8	3.2*	82.5	-.1*	77.9	-4.7*	74.7	-7.9*
09-10	57.7	0.0	59.3	1.6*	56.7	-1.3*	51.4	-6.3	0.0	0.0
10-11	78.3	0.0	80.2	1.9*	78.6	.3*	75.5	-2.8*	71.2	-7.1*
11-12	75.6	0.0	77.3	1.7*	74.6	-1.3*	71.6	-4.0*	67.4	-8.2*
12-13	75.2	0.0	76.8	1.6*	74.4	-.3*	70.1	-5.1*	74.8	-.4*
13-14	78.8	0.0	80.4	1.6*	79.1	.3*	76.5	-2.3*	75.1	-3.7*
14-15	72.5	0.0	75.3	2.8*	72.8	.3*	71.2	-1.3*	68.4	-4.1*
15-16	76.2	0.0	76.4	.2*	73.1	-3.1*	67.5	-8.7*	67.7	-8.5*
16-17	77.1	0.0	80.6	3.5*	79.1	2.0*	77.6	.5*	72.1	-5.0*
17-18	76.0	0.0	78.8	2.8*	76.8	.3*	74.3	-1.7*	70.4	-5.6*
18-19	72.4	0.0	74.3	1.9*	71.7	-.7*	68.1	-4.3*	68.6	-3.8*
----- EVENING -----										
19-20	79.6	0.0	82.6	3.0*	81.0	1.4*	78.9	-.7*	73.9	-5.7*
20-21	51.9	0.0	55.5	0.0	52.0	0.0	45.4	0.0	55.8	0.0
21-22	40.9	0.0	44.4	0.0	33.4	0.0	35.4	0.0	56.2	0.0
----- NIGHT -----										
22-23	75.5	0.0	75.4	-.1*	73.3	-2.2*	67.4	-8.1*	68.6	-6.9*
23-00	56.0	0.0	58.3	2.3*	58.5	2.5*	58.6	2.6*	57.3	1.3*

FIGURE E-3. HOURLY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A,
13 JANUARY 1981.

100

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE   01-14-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	50.7	0.0	51.6	0.0	50.5	0.0	51.6	0.0	0.0	0.0
01-02	50.9	0.0	55.5	0.0	50.6	0.0	44.2	0.0	0.0	0.0
02-03	52.8	0.0	54.8	0.0	51.6	0.0	50.5	0.0	56.6	0.0
03-04	38.0	0.0	48.4	0.0	35.6	0.0	0.0	0.0	0.0	0.0
04-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05-06	0.0	0.0	48.0	0.0	47.2	0.0	0.0	0.0	0.0	0.0
05-07	61.2	0.0	64.7	3.5*	60.5	-.7*	58.8	-2.4*	60.6	-.6*
----- DAY -----										
07-08	80.9	0.0	83.6	2.7*	80.7	-.2*	77.2	-3.7*	75.2	-5.7*
08-09	80.3	0.0	82.9	2.6*	78.8	-1.5*	74.7	-5.6*	74.2	-6.1*
09-10	79.8	0.0	82.0	2.2*	78.0	-1.8*	72.5	-7.3*	72.2	-7.6*
10-11	73.3	0.0	75.8	2.5*	75.2	1.9*	73.4	.1*	67.4	-5.9*
11-12	78.7	0.0	81.1	2.4*	78.7	0.0*	75.7	-3.0*	72.4	-6.3*
12-13	76.8	0.0	79.4	2.6*	77.5	.7*	73.8	-3.0*	72.8	-4.0*
13-14	79.7	0.0	81.2	1.5*	79.3	-.4*	75.6	-4.1*	75.1	-4.6*
14-15	75.2	0.0	77.5	2.3*	75.1	-.1*	71.9	-3.3*	70.8	-4.4*
15-16	62.5	0.0	64.4	1.9*	62.9	.4*	57.6	-4.9*	60.2	-2.3*
16-17	78.2	0.0	81.3	3.1*	77.9	-.3*	73.8	-4.4*	71.5	-6.7*
17-18	74.8	0.0	78.5	3.7*	77.1	2.3*	74.1	-.7*	70.8	-4.0*
18-19	76.3	0.0	79.9	3.6*	78.5	2.2*	75.8	-.5*	70.4	-5.9*
----- EVENING -----										
19-20	79.8	0.0	82.7	2.9*	80.3	.5*	75.1	-4.7*	71.7	-5.1*
20-21	52.6	0.0	54.1	0.0	50.9	0.0	43.7	0.0	55.8	0.0
21-22	54.4	0.0	56.2	0.0	55.2	0.0	51.9	0.0	0.0	0.0
----- NIGHT -----										
22-23	57.3	0.0	61.1	3.8*	59.3	2.0*	57.6	.3*	57.3	0.0*
23-00	51.9	0.0	52.0	0.0	54.2	0.0	56.0	0.0	57.2	0.0

FIGURE E-4.   HOURLY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A,
14 JANUARY 1981.

SITE COMPARISON ANALYSIS

DATE 01-15-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
CUMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	50.6	0.0	51.0	0.0	50.5	0.0	40.2	0.0	0.0	0.0
01-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-03	49.1	0.0	53.4	0.0	51.6	0.0	48.9	0.0	59.0	0.0
03-04	47.2	0.0	48.5	0.0	45.0	0.0	0.0	0.0	0.0	0.0
04-05	52.7	0.0	52.1	0.0	34.6	0.0	0.0	0.0	0.0	0.0
05-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06-07	62.2	0.0	65.1	2.9*	60.8	-1.4*	53.9	-8.3	60.0	-2.2*
----- DAY -----										
07-08	75.7	0.0	78.7	3.0*	74.7	-1.0*	70.0	-5.7*	73.6	-2.1*
08-09	80.5	0.0	83.0	2.5*	81.2	.7*	77.3	-3.2*	73.0	-7.5*
09-10	73.1	0.0	76.2	3.1*	75.4	2.3*	73.9	.8*	69.1	-4.0*
10-11	77.8	0.0	80.6	2.8*	77.6	-.2*	72.8	-5.0*	72.0	-5.8*
11-12	73.0	0.0	76.5	3.5*	75.4	2.4*	75.0	2.0*	67.2	-5.8*
12-13	76.4	0.0	79.4	3.0*	77.5	1.1*	71.3	-5.1*	68.6	-7.8*
13-14	70.6	0.0	74.5	3.9*	73.5	2.9*	68.9	-1.7*	67.6	-3.0*
14-15	77.9	0.0	79.0	1.1*	75.2	-2.7*	71.0	-6.9*	67.7	-10.2*
15-16	68.3	0.0	69.6	1.3*	68.7	.4*	64.8	-3.5*	62.1	-6.2*
16-17	73.9	0.0	75.9	2.0*	70.7	-3.2*	64.9	-9.0*	66.8	-7.1*
17-18	78.2	0.0	79.0	.8*	76.7	-1.5*	71.0	-7.2*	70.1	-8.1*
18-19	67.7	0.0	69.9	2.2*	69.0	1.3*	65.0	-2.7*	67.6	-.1*
----- EVENING -----										
19-20	76.1	0.0	78.0	1.9*	74.2	-1.9*	68.4	-7.7*	68.3	-7.8*
20-21	72.1	0.0	74.8	2.7*	73.9	1.8*	72.8	.7*	64.3	-7.8*
21-22	58.3	0.0	61.3	3.0*	59.0	.7*	57.2	-1.1*	56.7	-1.6*
----- NIGHT -----										
22-23	58.2	0.0	59.3	1.1*	58.7	.5*	54.6	-3.6	55.1	-3.1*
23-00	52.9	0.0	55.8	0.0	55.3	0.0	57.9	0.0	53.1	0.0

FIGURE E-5.   HOURLY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A,
15 JANUARY 1981.

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DATE 01-16-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	48.6	0.0	48.9	0.0	37.7	0.0	0.0	0.0	0.0	0.0
01-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-03	47.2	0.0	39.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05-06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06-07	60.5	0.0	62.2	1.7*	59.5	-1.0*	57.4	-3.1*	60.8	.3*
----- DAY -----										
07-08	77.5	0.0	80.3	2.8*	79.0	1.5*	76.9	-.6*	75.0	-2.5*
08-09	81.1	0.0	84.0	2.9*	82.4	1.3*	79.7	-1.4*	76.8	-4.3*
09-10	62.3	0.0	63.9	1.6*	61.1	-1.2*	59.1	-3.2*	61.1	-1.2*
10-11	62.0	0.0	62.0	0.0*	59.0	-3.0*	65.6	3.6*	62.6	.6*
11-12	60.7	0.0	62.6	1.9*	59.1	-1.5*	56.8	-3.9*	62.9	2.2*
12-13	73.2	0.0	75.4	2.2*	72.6	-.5*	65.1	-8.1*	65.6	-7.6*
13-14	60.3	0.0	60.8	.5*	56.3	-4.0*	54.6	-5.7	63.3	3.0*
14-15	57.2	0.0	60.1	2.9*	55.0	-2.2*	52.3	-4.9	63.7	6.5*
15-16	54.0	0.0	57.8	0.0	54.9	0.0	50.4	0.0	62.4	0.0
15-17	80.9	0.0	82.3	1.4*	76.3	-4.5*	69.6	-11.3*	70.1	-10.8*
17-18	78.1	0.0	80.2	2.1*	77.7	-.4*	74.8	-3.3*	74.0	-4.1*
18-19	61.1	0.0	64.1	3.0*	61.6	.5*	60.1	-1.0*	62.1	1.0*
----- EVENING -----										
19-20	80.2	0.0	82.7	2.5*	79.0	-1.2*	73.3	-6.9*	70.9	-9.3*
20-21	76.7	0.0	79.4	2.7*	78.6	1.9*	75.1	-1.6*	68.9	-7.8*
21-22	56.1	0.0	59.5	3.4*	55.6	.5*	55.6	-.5*	61.9	5.8*
----- NIGHT -----										
22-23	52.3	0.0	51.4	0.0	51.4	0.0	54.6	0.0	49.9	0.0
23-00	50.2	0.0	51.4	0.0	47.3	0.0	46.7	0.0	0.0	0.0

FIGURE E-6. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 16 JANUARY 1981.

SITE COMPARISON ANALYSIS

DATE 01-17-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	0.0	0.0	53.7	0.0	34.2	0.0	0.0	0.0	0.0	0.0
01-02	43.3	0.0	43.2	0.0	45.9	0.0	46.9	0.0	0.0	0.0
02-03	81.4	0.0	80.2	-1.2*	80.4	-1.0*	71.5	-9.9*	73.6	-7.8*
03-04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04-05	0.0	0.0	0.0	0.0	39.7	0.0	33.4	0.0	0.0	0.0
05-06	41.6	0.0	50.5	0.0	31.4	0.0	0.0	0.0	0.0	0.0
05-07	51.8	0.0	52.7	0.0	47.0	0.0	41.3	0.0	51.8	0.0
----- DAY -----										
07-08	67.4	0.0	70.2	2.8*	69.0	1.5*	66.5	-.9*	70.0	2.6*
08-09	67.5	0.0	69.0	1.5*	67.7	.2*	65.8	-1.7*	72.2	4.7*
09-10	57.1	0.0	58.7	1.6*	55.8	-1.3*	53.6	-3.5	59.9	2.8*
10-11	60.5	0.0	61.4	.9*	57.3	-3.2*	55.6	-4.9*	64.9	4.4*
11-12	58.7	0.0	60.0	1.3*	56.3	-2.4*	53.5	-5.2	63.4	4.7*
12-13	61.6	0.0	62.9	1.3*	59.3	-2.3*	56.9	-4.7*	65.5	3.9*
13-14	63.0	0.0	62.4	-.6*	62.4	-.5*	61.9	-1.1*	65.9	2.9*
14-15	43.4	0.0	50.0	0.0	34.9	0.0	0.0	0.0	0.0	0.0
15-16	60.1	0.0	62.3	2.2*	58.1	-2.0*	51.9	-8.2	61.6	1.5*
15-17	66.9	0.0	70.4	3.5*	69.7	2.3*	68.8	1.9*	67.4	.5*
17-18	73.3	0.0	76.2	2.9*	74.4	1.1*	71.9	-1.4*	69.2	-4.1*
18-19	74.2	0.0	75.8	1.6*	74.1	-.1*	70.9	-3.3*	69.8	-4.4*
----- EVENING -----										
19-20	74.4	0.0	76.2	1.8*	74.9	.5*	72.4	-2.0*	67.5	-6.9*
20-21	40.4	0.0	54.7	0.0	40.8	0.0	0.0	0.0	0.0	0.0
21-22	43.0	0.0	51.2	0.0	47.8	0.0	0.0	0.0	0.0	0.0
----- NIGHT -----										
22-23	0.0	0.0	31.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23-00	48.6	0.0	48.0	0.0	50.2	0.0	43.0	0.0	0.0	0.0

FIGURE E-7. HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 17 JANUARY 1981.

SITE COMPARISON ANALYSIS

DATE 01-18-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	50.1	3.0	51.1	0.0	49.5	0.3	44.6	0.0	0.0	0.0
01-02	49.6	3.0	52.5	0.0	49.6	0.3	47.2	0.0	0.0	3.0
02-03	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
03-04	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
04-05	48.1	3.0	56.5	0.0	49.5	0.3	0.0	0.0	0.0	0.0
05-06	0.0	0.0	0.0	0.0	3.0	0.3	0.0	0.0	0.0	0.0
06-07	0.0	0.0	33.2	0.0	3.0	0.3	0.0	0.0	0.0	0.0
----- DAY -----										
07-08	67.7	3.0	70.3	2.6*	69.6	1.9*	69.1	1.4*	59.8	2.1*
08-09	73.8	0.0	75.8	2.0*	73.1	-.7*	68.9	-4.9*	65.5	-8.3*
09-10	59.4	0.0	59.9	.5*	59.2	-.2*	57.4	-2.0*	60.3	.9*
10-11	68.7	0.0	71.6	2.9*	72.8	4.1*	72.7	4.0*	69.5	.8*
11-12	75.0	0.0	76.8	1.8*	75.2	.2*	69.4	-5.6*	67.3	-7.7*
12-13	75.5	3.0	77.5	2.0*	75.4	-.1*	69.5	-6.0*	68.8	-6.7*
13-14	69.4	0.0	73.1	3.7*	72.4	3.0*	70.4	1.0*	66.9	-2.5*
14-15	60.5	0.0	63.5	3.0*	60.3	-.2*	55.1	-5.4*	61.5	1.0*
15-16	72.8	3.0	75.5	2.7*	74.8	2.0*	72.4	-.4*	66.2	-6.6*
16-17	70.2	3.0	70.8	.6*	69.8	-.4*	66.9	-3.3*	66.3	-3.9*
17-18	75.3	0.0	77.4	2.1*	75.9	.5*	73.2	-2.1*	70.0	-5.3*
18-19	72.3	0.0	73.8	1.5*	71.1	-1.2*	65.2	-7.1*	67.7	-4.6*
----- EVENING -----										
19-20	80.0	0.0	82.9	2.9*	78.9	-1.1*	73.7	-6.3*	72.1	-7.9*
20-21	73.3	0.0	77.3	4.0*	75.3	2.0*	69.8	-3.5*	66.6	-6.7*
21-22	58.0	0.0	63.7	5.7*	56.4	-1.5*	49.3	-8.7	58.1	.1*
----- NIGHT -----										
22-23	0.0	3.0	0.0	0.0	3.0	0.3	0.0	0.0	0.0	3.0
23-00	44.3	0.0	47.9	0.0	48.7	0.3	46.9	0.0	0.0	0.0

FIGURE E-8. HOURLY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A,
18 JANUARY 1981.

S I T E   C O M P A R I S O N   A N A L Y S I S

DATE   01-19-81

REFERENCE SITE = 2036
REFERENCE HNL ACCEPTANCE THRESHOLD = 55.0
COMPARISON HNL ACCEPTANCE THRESHOLD = 55.0

	2036		2141		2029		1910		0001	
HOUR	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA	HNL	DELTA
----- NIGHT -----										
00-01	46.3	0.0	49.8	0.0	50.5	0.0	49.8	0.0	0.0	0.0
01-02	40.4	0.0	39.3	0.0	37.2	0.0	40.6	0.0	0.0	0.0
03-04	0.0	0.0	49.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04-05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05-06	62.9	0.0	64.5	1.6*	61.7	-1.2*	56.9	-6.0*	55.9	-7.0*
06-07	49.8	0.0	48.8	0.0	48.3	0.0	46.8	0.0	51.7	0.0
----- DAY -----										
07-08	81.2	0.0	82.4	1.2*	80.1	-1.1*	78.5	-2.7*	77.4	-3.8*
08-09	79.7	0.0	81.4	1.7*	75.8	-3.9*	69.6	-10.1*	70.4	-9.3*
09-10	71.2	0.0	72.3	1.1*	70.6	-.5*	68.1	-3.1*	70.0	-1.2*
10-11	72.0	0.0	72.8	.8*	70.5	-1.5*	66.2	-5.8*	65.6	-6.4*
11-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.4	0.0
12-13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.7	0.0
13-14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.9	0.0
14-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.0	0.0
15-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	58.5	0.0
16-17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	66.8	0.0
17-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.0	0.0
18-19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.6	0.0
----- EVENING -----										
19-20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	72.9	0.0
20-21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.7	0.0
21-22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
----- NIGHT -----										
22-23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	53.4	0.0
23-00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	54.9	0.0

FIGURE E-9.   HOURLY AIRCRAFT NOISE LEVEL COMPARISON AT 5 SITES IN INTERVIEW NEIGHBORHOOD A, 19 JANUARY 1981.

Selecting one auxiliary site at a time, hourly sound levels
were compared with the central site on an hour-by-hour
basis. To be included in the analysis, hourly levels at
both sites had to exceed a value of 55 dB, the lowest
probable value for a single jet overflight during the
hour. The results are shown in Figure E-10, comparing
the four auxiliary sites (2141, 2029, 1910, and 0001)
individually with the central site (2036). Analyses are
shown for daytime hours (0700 to 1859), evening hours
(1900 to 2159), nighttime hours (2200 to 0659), and the
entire 24 hour day. Shown in the first column (labeled "N")
is the sample size (i.e., the number of hours satisfying the
aforementioned 55 dB criterion. In the next two columns
are the energy average sound levels for the auxiliary and
central sites, respectively, with the "DIFF" column show-
ing the energy difference between the two sites. The
remaining two columns (labeled "MEAN" and "DEV") show the
arithmetic mean and standard deviation of the individual
hourly differences shown in the "DELTA" columns of Figures
E-2 through E-9.

Although the differences for the individual periods of the
day show some weak trends, the sample size is too small to
draw firm conclusions. The trends that do exist (the lesser
difference at night than during the day and evening) are
probably the result of subtle differences in departure
procedures after dark. The small number of night departures
contribute negligibly, however, to overall daily exposure.

Both the energy and arithmetic differences of the 24
hour statistics agree extremely well, except at auxi-
liary site 0001 (outside the interviewing area). This
agreement strongly suggests that the differences are level

S I T E   C O M P A R I S O N   A N A L Y S I S
(S U M M A R Y)

	N	ENERGY AVG HNL			HNL DIFFERENCE	
		SITE 2141	SITE 2036	DIFF	MEAN	DEV
DAY	80	78.5	76.2	2.3	2.1	.9
EVENING	13	79.7	76.8	2.9	3.1	1.0
NIGHT	12	71.1	71.8	-.7	1.8	1.4
24 HOUR	105	78.2	75.9	2.3	2.2	1.1

	N	ENERGY AVG HNL			HNL DIFFERENCE	
		SITE 2029	SITE 2036	DIFF	MEAN	DEV
DAY	79	75.8	76.1	-.2	-.3	1.8
EVENING	13	77.4	76.8	.5	.4	1.4
NIGHT	11	71.0	72.2	-1.2	-.3	1.5
24 HOUR	103	75.8	75.9	-.1	-.2	1.7

	N	ENERGY AVG HNL			HNL DIFFERENCE	
		SITE 1910	SITE 2036	DIFF	MEAN	DEV
DAY	73	72.8	76.4	-3.6	-3.4	3.1
EVENING	12	74.1	77.2	-3.1	-2.9	2.8
NIGHT	8	64.6	73.5	-8.9	-3.6	4.2
24 HOUR	93	72.7	76.3	-3.6	-3.4	3.1

	N	ENERGY AVG HNL			HNL DIFFERENCE	
		SITE 0001	SITE 2036	DIFF	MEAN	DEV
DAY	80	71.0	76.2	-5.2	-3.6	4.0
EVENING	13	69.8	76.8	-7.0	-5.3	4.3
NIGHT	11	65.3	72.2	-6.9	-2.1	3.8
24 HOUR	104	70.5	76.0	-5.5	-3.5	4.0

FIGURE E-10.   SUMMARY AIRCRAFT NOISE LEVEL COMPARISON
AT 5 SITES IN INTERVIEW NEIGHBORHOOD A.

independent; that is, HNL's at the auxiliary sites tend to differ from those of the central site by roughly constant amounts, regardless of absolute level. This observation is based on the greater sensitivity of the energy comparison to the higher levels, and the equal sensitivity of the arithmetic comparison to all levels. The 2 dB discrepancy observed at site 0001 suggests that the HNL difference is smaller at lower levels than at high levels. This may be the result of higher sound level jet aircraft making straight out departures and lower level general aviation aircraft turning right shortly after takeoff.

Comparison of the 24 hour energy average HNL differences in Figure E-10 with the energy average L_{dn} differences in Table E-1 reveals agreement within $\pm$ 0.1 dB. It is therefore concluded that the values shown in Table E-1 are free of any unusual anomalies and can be used with confidence in further comparisons with the noise contours shown in Figure E-1.

Table E-2 compares the measured inter-site L_{dn} differences (shown in Table E-1) with the estimated inter-site differences from the L_{dn} contours of Figure E-1. Note that the measurements confirm the contour estimates to within $\pm$1 decibel. Thus, the contours of Figure 6 can be used as a means for estimating the noise exposure gradient across interview neighborhoods with a high accuracy.

Table E-2 also shows that monitor site 2029, selected to provide a second central tendency measurement, is in very close agreement with the original central site. Varying the personnel involved in site selection and instrument deployment had little effect on the measurement results.

TABLE E-2. VARIATION IN NOISE EXPOSURE ACROSS NEIGHBORHOOD A

Monitoring Site	L_{dn}, re: Central Site (2036)	
	Measured Values*	Estimated Values from Contours
2141	+2.3 dB	+2.0
2029	−0.2	−0.5
1910	−3.7	−2.5
0001**	−5.5	−4.4

  * From Table E-1
 ** Immediately west of Neighborhood A

APPENDIX F

BACKGROUND INFORMATION FOR ESTIMATION OF TIME COURSE OF CHANGES IN COMMUNITY ANNOYANCE DUE TO CHANGES IN AIRCRAFT NOISE EXPOSURE

As noted in the Discussion Section of this report, the general form of the exponential relationship between change in annoyance as a function of change in exposure is assumed to be

$$P(t) = P(\infty) + \Delta P \cdot e^{-t/T}$$

where: t = elapsed time since noise exposure change, in days

    T = time constant of attitude change, in days

    $P(t)$ = percent highly annoyed at time t

    $P(\infty)$ = percent highly annoyed after long term adaptation to changed noise exposure

    ΔP = difference between percent highly annoyed before exposure change and long after change.

The strategy for determining T, given only four rounds of inter-views (and thus four $(t, P(t))$ data points) was to estimate values of $P(\infty)$ and ΔP and then iteratively select the value of T which generated the smallest mean square error between the observed and predicted percent highly annoyed.

Values of $P(\infty)$ and ΔP were derived in two different ways to permit assessment of the sensitivity of the prediction to the estimated values. It was observed first that before a change in exposure had occurred (Interview Round 1) peoples' attitudes regarding annoyance due to aircraft over the past _year_ (Question 4) and past _week_ (Question 3) were virtually identical. That is, after a long period of habituation to an unchanging noise envi-ronment one could infer attitudes about the past year from those

stated for the past week. If the assumption is made that people have habituated after 2 months of exposure to the new environment, a reasonable estimate of $P(\infty)$ may be made by averaging the percent highly annoyed to aircraft over the past week from Interview Rounds 3 and 4.

A second method for estimating $P(\infty)$ uses the relationship of Schultz (1978) to extrapolate existing attitudes before the exposure change to those a long time after the change. Figure F-1 shows graphically how this was accomplished. First a data point corresponding to L_{dn} and percent highly annoyed from Question 4 of Round 1 is plotted. A more stable estimate of percent highly annoyed before the change was obtained by averaging the values from both Rounds 1 and 2. Round 2 took place only two weeks after the change in noise exposure and there is no significant difference in responses to Question 4 between these rounds.

Next, Schultz's curve is made to pass through this data point by moving the curve horizontally until agreement is reached. Finally, an estimate of the long term average noise exposure after the change is obtained by averaging the measured L_{dn}'s over Interview Rounds 2, 3, and 4. Entering the curve with this L_{dn} value, the percent highly annoyed is read from the shifted curve and used as the estimated value of $P(\infty)$.

Values of ΔP were obtained by taking the difference between the average percent highly annoyed to aircraft over the past year from interview Rounds 1 and 2 and the previously determined values of $P(\infty)$.
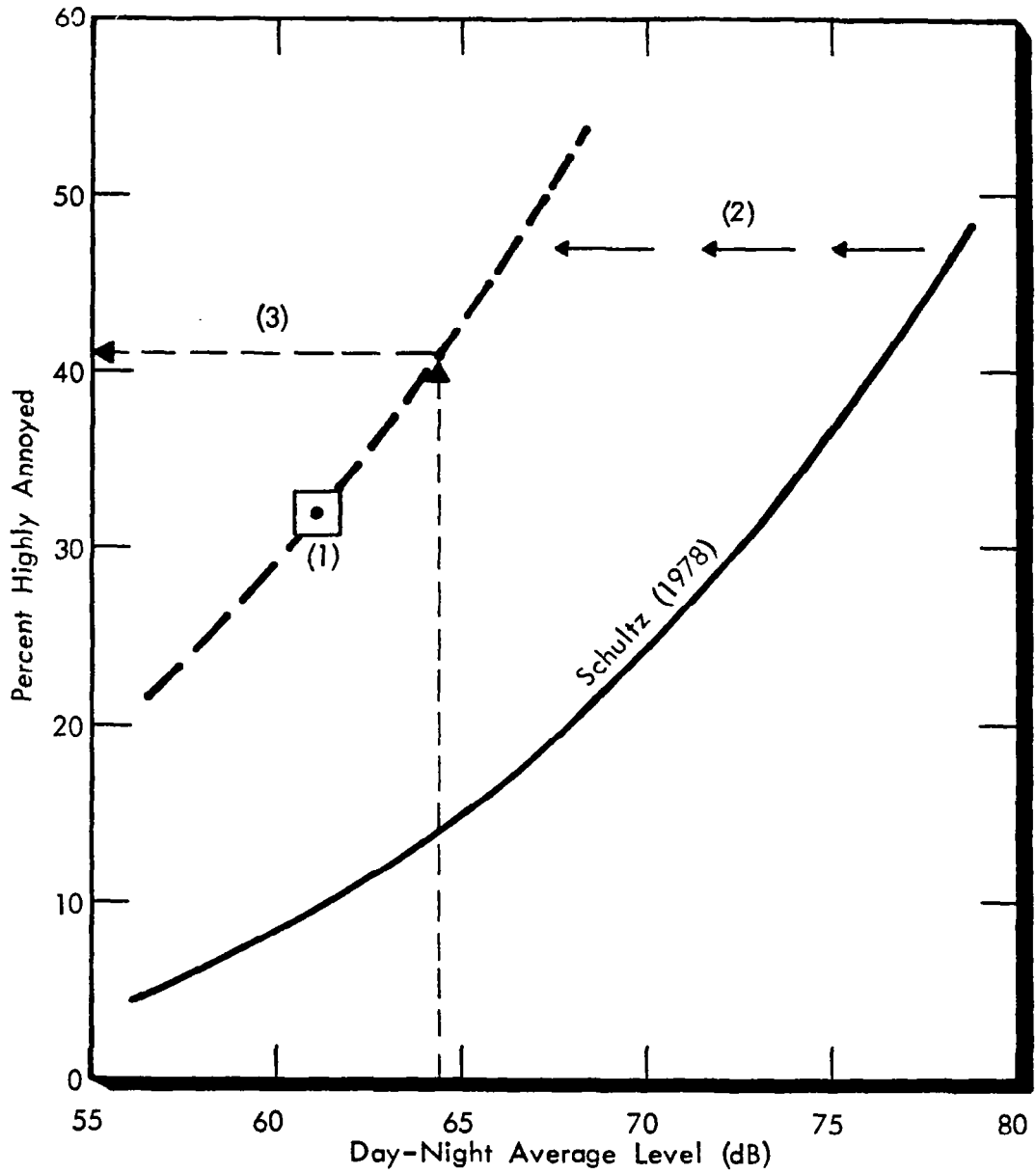
FIGURE F-1. GRAPHICAL METHOD FOR ESTIMATING ATTITUDINAL CHANGE TO A CHANGE IN NOISE ENVIRONMENT.

Table F-I lists the observed values of L_{dn} and percent highly annoyed to aircraft over the past year. Table F-II shows the estimated values of $P(\infty)$, ΔP and T under the various assumptions stated above. In addition, selected values of $P(\infty)$ were perturbed ±10 percent to examine the sensitivity of the estimated value of T to changes in $P(\infty)$.

Finally, the constants of Table F-II were used in the equation such that the best fitting exponential curves and the raw data points could be plotted, as shown in Figure F-2. These figures also show the step change in noise exposure for each neighborhood. The two graphs shown for each community are, in fact, the input and output functions analogous to those of Figure 1.

It may be seen from Table F-II that the estimated value of the time constant, T, is in most cases quite sensitive to the estimated value of $P(\infty)$ (the asymptotic level of annoyance).
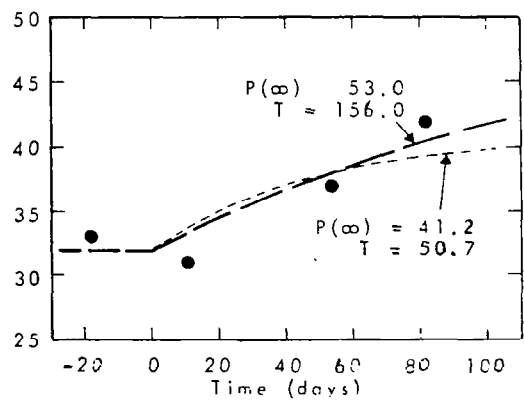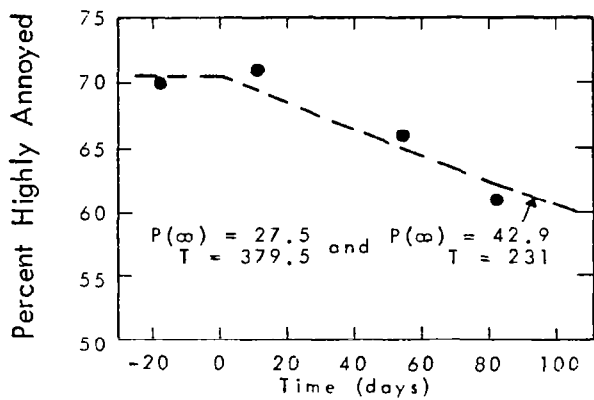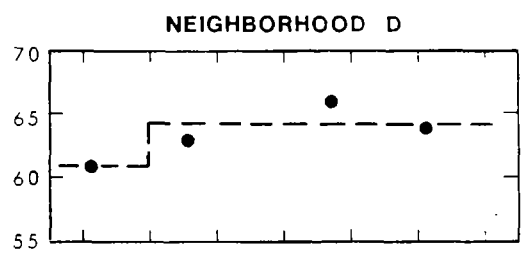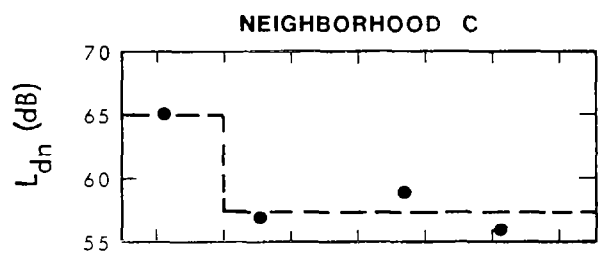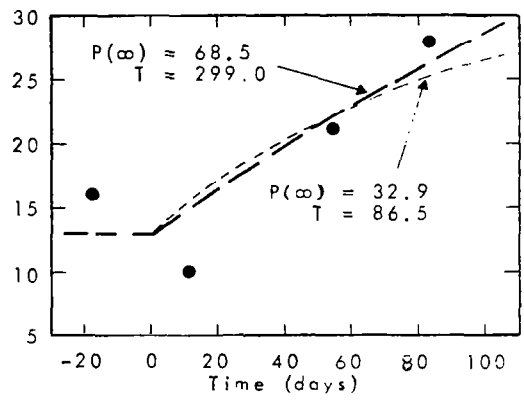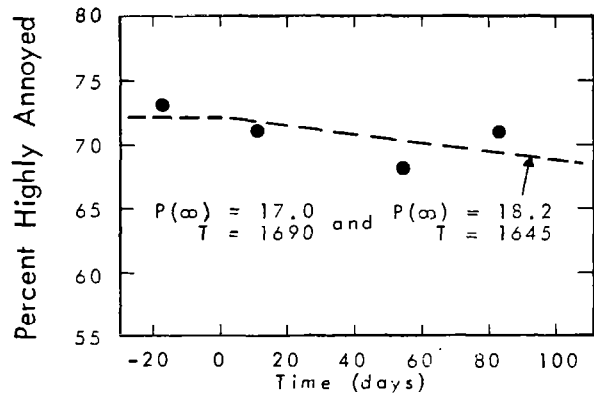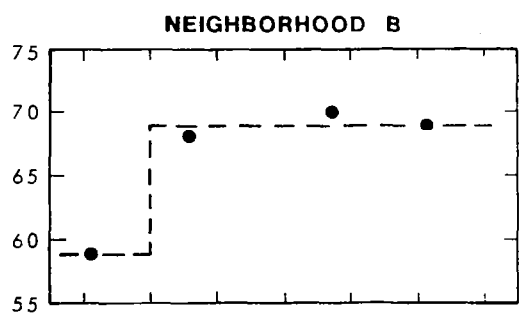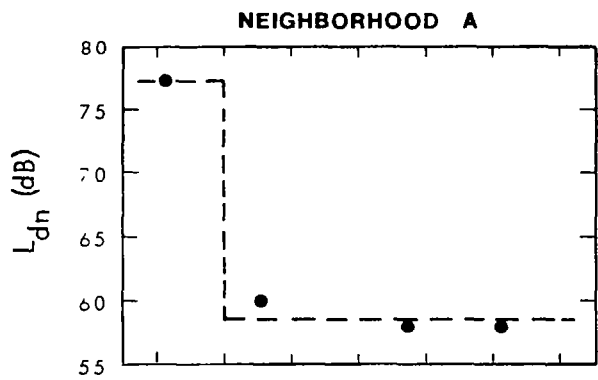
FIGURE F-2. OBSERVED HISTORY OF EXPOSURE AND ANNOYANCE TO PAST YEAR.

TABLE F-I. L_{dn} AND PERCENT HIGHLY ANNOYED (AIRCRAFT OVER PAST YEAR) AS A FUNCTION OF TIME

Days After Runway Closure (t)	Neighborhood A		Neighborhood B		Neighborhood C		Neighborhood D	
	L_{dn}	%HA (P[t])	L_{dn}	%HA (P[t])	L_{dn}	%HA (P[t])	L_{dn}	%HA (P[t])
-13 (0)	77 dB	73	59 dB	16	65 dB	70	61 dB	33
11	60	71	68	10	57	71	63	31
54	58	68	70	21	59	66	66	37
82	58	71	69	28	56	61	64	42

TABLE F-II.   ESTIMATED TIME CONSTANTS FOR VARIOUS ASSUMED

ASYMPTOTIC VALUES OF PERCENT HIGHLY ANNOYED

P (∞) Assumption	NEIGHBORHOOD A			NEIGHBORHOOD B			NEIGHBORHOOD C			NEIGHBORHOOD D		
	%HA (P[∞])	Change in %HA (ΔP)	Estimated Time Constant (T)	%HA (P[∞])	Change in %HA (ΔP)	Estimated Time Constant (T)	%HA (P[∞])	Change in %HA (ΔP)	Estimated Time Constant (T)	%HA (P[∞])	Change in %HA (ΔP)	Estimated Time Constant (T)
(1)	17.0	55.0	1690	68.5	-55.5	299.0	27.5	43.0	379.5	53.0	-21.0	156.0
(2)	18.2	53.8	1645	32.9	-19.7	86.5	42.9	27.6	231.0	41.2	- 9.2	50.7
(3)	16.4	55.6	1710	29.6	-16.6	67.5	38.6	31.9	272.5	37.1	- 5.1	25.2
(4)	20.0	52.0	1590	36.2	-23.2	106.0	47.2	23.3	190.0	45.3	-13.3	86.5

(1)   Average of "aircraft over past week", interview rounds 3 & 4

(2)   Estimated from Shultz (1978) curve (see text for details)

(3)   Same as (2) plus 10%

(4)   Same as (2) minus 10%.

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15. Supplementary Notes

Langley Technical Monitor: David G. Stephens
Final Report for TASK 33

16. Abstract

Four rounds of interviews were conducted in the vicinity of Burbank
Airport during a four-month period during which a counterbalanced series
of changes in aircraft noise exposure occurred due to runway repairs.
A fifth round of interviewing was undertaken approximately one year
after completion of the initial runway repairs. Noise measurements
were made in conjunction with administration of a brief questionnaire
to a near-exhaustive sample of residents in four airport neighborhoods.
The magnitude and direction of change of annoyance with aircraft noise
exposure corresponded closely to the actual changes in physical
exposure. Estimates were made of time constants for the rate of
change of attitudes toward aircraft noise.

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