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THE UNBEARABLE MENACE -- AIRPORT NOISE

Noise, defined as unwanted sound, surrounds the urban dweller in a never-ending excessive and gradually increasing din of decibels. No one is exposed more intolerably than the citizen who resides in close proximity to a major airport.

Exposure of humans to noise can result in both mental and physical distress. While the most noticeable effect of noise exposure involves the hearing mechanism, certain noises may result in non-auditory distress such as alterations in respiration, circulation, basal metabolic rate, and muscle tension. These physical effects are primarily related to intensity and frequency of the offending sound.

Equally important and very likely more important than the physical manifestations are the possible psychologic effects. Psychologic reactions involve a multiplicity of factors which vary with the characteristics of the sound -- the inappropriateness of the stimulus, unexpectedness of the noise, interference with speech communication, and intermittancy, as well as its intensity and frequency. The quality of the noise rather than the quantity is usually the deciding factor in influencing the emotional reactions to noise.

No doubt the most widespread reaction to noise is that of annoyance. Certain characteristics of sound appear more annoying than others. These characteristics are:

1. Loudness - the more intense, louder noises are considered more annoying.

2. Pitch - a high pitch noise is generally more annoying than a low pitch noise of equal loudness.

3. Intermittancy and irregularity - sound that occurs randomly or varies in intensity or frequency appears to be more annoying than continuous or unchanging sounds.

4. Localization - a sound which appears to change its relative location to the listener is more annoying than a stationary source.

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Aircraft noise certainly fits all of these criteria for annoyance.

In addition to annoyance, two of the chief complaints concerning aircraft noise involve the interference with speech and the disturbance of sleep and relaxation.

DISTURBANCE OF SLEEP

Disturbance of sleep is of primary importance because of its necessity for "normal" psychologic and physiologic functioning. Aggravated sleep loss may have a profound effect on body health, particularly for the aged, the sick and the very young. Recent testimony before a legislative committee on jet noise in New York City cited paranoid delusions, hallucinations, suicidal and homocidal impulses as some of the possible consequences of continued sleep loss.

Effects of noise on sleep have been observed by studying brain wave patterns utilizing an electroencephalograph. Indications are that quality of sleep may be impaired by shifts from deeper stages to shallower stages or by the interruption of dream sequences.

A study by Jensen concerned the sleep sensitivity of seven subjects for 120 nights who were exposed to noise from 300 milliseconds to 90 minutes duration. Results indicated that even the deepest stages of sleep were influenced by noise intensities from 60 to 65 dBA.

Thiessen exposed a number of sleeping subjects to a recording of truck noise from 40 to 70 dBA on different nights at a constant level. His results indicated that at 70 dBA the most probable reaction would be to awaken from sleep. At 50 dBA approximately 50% of the subjects would change to a less-deep sleep or awaken, and at 40 to 45 dBA approximately 10% of those so exposed will respond by changing the depth of sleep or awaken.

J.D. Miller, Effects of Noise on People, Central Institute for Deaf (1971), concluded that all factors being considered, one must tentatively assume that sleep disturbance by excessive noise will reduce one's feeling of well being. Furthermore, when noise conditions are so severe as to disturb sleep on a regular and unrelenting basis, then such sleep disturbances may constitute a hazard to one's mental and physical health.

At the request of a number of citizens residing adjacent to the Seattle-Tacoma Airport, a noise survey was conducted to determine the effect of aircraft traffic on the noise environment. Continuous noise measurements were conducted inside a mobile camper at four locations on the borderline between Zone 3 and Zone 2. According to the Federal Housing Authority, most homes located in Zone 3 because of excessive noise and strong jet and fuel odor would be ineligible for FHA mortgage insurance.

The camper of modest size was utilized to represent indoor measurements utilizing the same structure.

Results of this investigation are shown in Tables 1, 2, and 3. It should be noted that for a significant amount of time each day (Table 3) ranging from 53 minutes to 103 minutes, the noise levels exceeded 60 dBA. During the 24 hours of measurement at location 1 (Table 1) there were a total of 161 flyovers, of which 135 were over 75 dBA, with the maximum noise level being 91 dBA. At location 2 there were 151 flyovers with 125 exceeding 75 dBA, and at location 4 for a 20-hour period there were 116 exceeding 75 dBA. The maximum noise levels at locations 2 and 4 were 95 dBA.

During sleeping hours, 10 p.m. to 7 a.m., at Locations 1, 2, and 4, there were 29, 34, and 26 flyovers, with the number of peaks over 75 dBA being 25, 29, and 25. Maximum noise levels ranged from 89 to 94 dBA (Table 3).

Noise levels determined during this limited investigation would definitely be considered excessive and over a long period of time could have an adverse effect on the mental health and physical well being as a result of periodic awakenings and/or changes in depth of sleep. A number of people living in this area mentioned that their children were at times sent home from school as the result of dozing or falling asleep in class.

Such exposures as mentioned above could be of major significance even during daytime hours for children under one year of age who sleep most of the day, for children 1 to 5 who nap during the day, for the aged and sick, and for those who work nights.

INTERFERENCE WITH SPEECH IN SCHOOLS

The problem of noise in some schools has already reached the critical stage, particularly for those structures located adjacent to airports and freeways. The quantity and quality of noise in schools may produce adverse psychologic effects, interfere with study habits, and interfere with comprehension of the spoken word.

Since speech and its understanding are vital to the learning process, optimization of the sonic environment for the purposes of communication is desirable. One of the requirements for good listening conditions is that the background or interfering noise not be too intense. It therefore is imperative that the background or ambient sound be controlled to a relatively low intensity. Ambient noise is the noise present in the space with all systems (air conditioning, etc.) operating normally, but with no students present.

A measure of noise known as the Preferred Speech Interference Level (PSIL) and estimates of it by the A-weighted decibel level (dBA) has recently been proposed as a useful tool for evaluating this aspect of noise. The PSIL is the arithmetic average of the sound pressure levels in the octave bands centered around the 500, 1000, and 2000 Hertz (Hz). Table 4 is a summary of the PSIL and comparable dBA readings that will barely permit acceptable speech intelligibility at various distances and noise levels.

TABLE-1 NOISE MEASUREMENTS - 4 LOCATIONS - ZONE 3

TIME	PEAKS ABOVE 75 dBA				MAX. dBA				TOTAL NO. FLYOVERS			
	1	2	3	4	1	2	3	4	1	2	3	4
10AM-11	6				90+				11			
11-12PM	6				90+				8			
12-1	10	12			89	91			12	14		
1-2	6	8			84	88			7	8		
2-3	3	8	13		87	91	92		4	11	13	
3-4	3	8	10		90	92	94		4	11	10	
4-5	9	5		6	90	91		94	9	7		6
5-6	11	13		9	91	95		95	11	14		9
6-7	6	6		9	89	91		95	7	6		9
7-8	8	8		9	89	91		95	8	8		9
8-9	3	3		12	82	87		94	5	3		12
9-10	7	7		12	88	92		94	10	8		12
10-11	4	6		5	86	87		91	5	6		5
11-12AM	5	5		2	89	92		91	6	5		2
12-1	5	5		8	86	91		87	5	5		8
1-2	3	2		4	81	89		88	4	2		4
2-3	2	2		1	81	89		80	2	2		1
3-4	1	1		1	78	76		91	1	1		1
4-5	0	3	3	3		83	86	94	0	3	4	3
5-6	2	5	0	1	81	81		94	2	7	0	1
6-7	3	0	3	0	83	72	88	70	4	3	3	1
7-8	10	0	12	2	84	74	90	87	14	2	12	8
8-9	13	4	10	7	88	83	88	94	13	4	11	8
9-10	9	4	1	6	90	80	76	92	9	5	2	6
10-11		6	0	7		81	75	92		9	9	7
11-12PM		4	1	12		90	79	94		7	8	14
TOTAL.												

TABLE 2. SUMMARY OF NOISE MEASUREMENTS - 4 LOCATIONS - ZONE 3

SOUND PRESSURE LEVEL dBA	LOCATION - 1		LOCATION - 2		LOCATION - 3		LOCATION - 4	
	TIME		TIME		TIME		TIME	
	HOURS	MIN.	HOURS	MIN.	HOURS	MIN.	HOURS	MIN.
LESS THAN 30		0				1		2
30 - 37.5		13		0.6		1		
37.5 - 45	1	4		0.6		32	6	32
45 - 52.5	19	12	21		10	2	9	56
52.5 - 60	1	14	1	30		10	2	56
60 - 67.5		40		36		29	3	20
67.5 - 75		32		27		10	1	50
75 - 82.5		21		23		4		12
82.5 - 90		7		9		0.5		7
90 - 91.5		2		1				1.1
91.5 - 105		0.5						
OVER 105								

TABLE 3. SUMMARY OF NOISE MEASUREMENTS DURING SLEEPING HOURS - (10PM - 7AM) 4 LOCATIONS · ZONE 3

LOCATION	PEAKS ABOVE 75dBA	MAX. dBA.	NO. FLYOVERS
1	25	89	29
2	29	92	34
3			
4	25	94	26

In most classrooms the maximum distance between student and instructor rarely exceeds 25 feet. Referring to Table 4, it should be noted that for effective speech intelligibility at 25 feet utilizing a "normal voice" the PSIL should not be greater that 41, which corresponds to 48 dBA. To provide a margin of safety, a background ambient level below 45 dBA would undoubtedly result in a reasonable acoustic environment. With a background noise level of 50 to 60 dBA in the classroom, a voice level from "raised" to "loud" would be required for speech intelligibility at 25 feet, and such a condition would be considered undesirable. When the background level exceeds 60 dBA, most students would have a difficult time hearing even a loud voice. Therefore, levels above 60 dBA would be unacceptable and time spent above 60 dBA could be considered as time lost from the instructional process.

Continuous monitoring of A-scale measurements was accomplished in 12 schools located adjacent to the Seattle-Tacoma Airport (Figure 1). All data was collected during the summer vacation period when there were no students in attendance. A number of different locations in each school were selected including portable units; measurements were made with windows closed, as well as open. Since the schools were not air conditioned, during warm days it was necessary to keep windows open for ventilation. Weather conditions, take-off direction, and street traffic conditions, where appropriate, were also noted.

The results of this investigation (Table 5) indicated that all schools with windows open and closed experienced noise levels in excess of 60 dBA. With windows open this unacceptable condition ranged from 3.3 hours at school No. 6 to 15 minutes at school No.8. Maximum noise levels ranged from a high of 98 dBA to a low of 80 dBA. In two of the schools (Nos.5 and 6) street traffic conditions contributed appreciably to the background noise.

In addition to the unacceptable conditions (over 60 dBA), all schools experienced significant times in the undesirable range of 50 to 60 dBA.

The author was present in one of the classrooms (with school in session) as a jet aircraft was passing overhead. It was observed that the instructor perceived the aircraft off at a distance and as the jet approached the school, the instructor's voice increased in intensity until he could no longer be heard. He then stopped speaking and after the aircraft passed the building, he began to speak in a loud voice that gradually got softer as the noise subsided. The maximum noise level during this period was 98 dBA. A noise level in excess of 110 dBA was experienced outside the school building during this same flyover. It was not uncommon for approximately 70 or more aircraft to pass directly over this school during the school day. Many teachers complained of the difficulty in operating under such trying conditions. Incidentally, the aircraft passed directly over one of the schools at an altitude of approximately 300 feet during landing, presenting a definite safety hazard potential.

Noise levels in all schools were excessive from the standpoint of speech interference requiring some degree of sound control to lower background noise levels to 45 dBA. In some schools, because of the relatively high maximum

TABLE- 4. PREFERRED SPEECH INTERFERENCE LEVELS (PSIL) THAT PERMIT BARELY ACCEPTABLE SPEECH INTELLIGIBILITY AT THE DISTANCE BETWEEN SPEAKER AND LISTENER AND VOICE LEVELS SHOWN. COMPARABLE LEVELS OF "A"- WEIGHTED NETWORK (dBA) ARE GIVEN.

DISTANCE (FEET)	VOICE LEVEL					
	NORMAL		RAISED		LOUD	
	PSIL	dBA	PSIL	dBA	PSIL	dBA
2	63	70	69	76	75	82
5	55	62	61	68	67	74
10	49	56	55	62	61	68
15	45	52	51	58	58	65
20	43	50	49	56	55	62
25	41	48	47	54	53	60

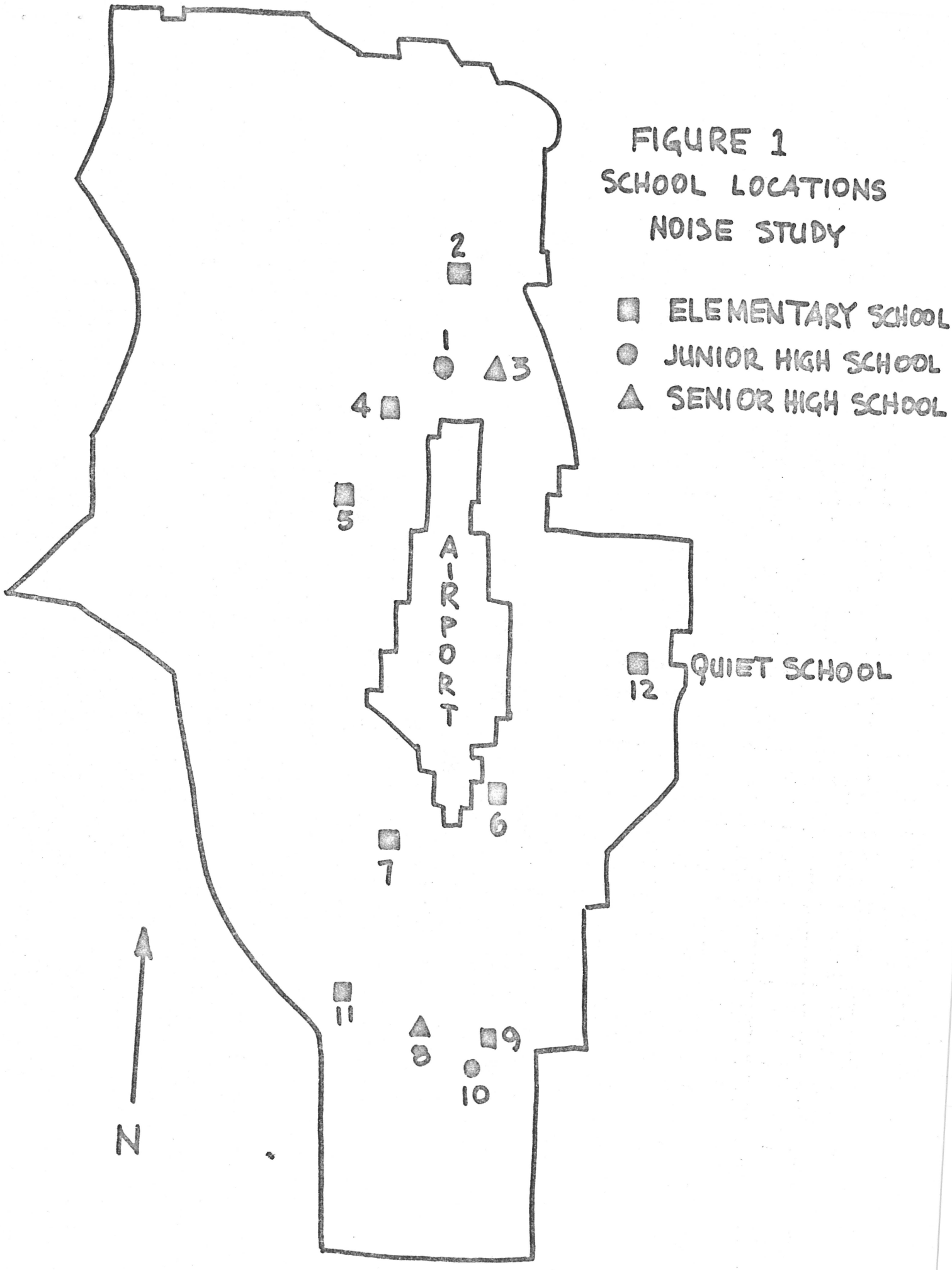
FIGURE 1
SCHOOL LOCATIONS
NOISE STUDY
ELEMENTARY SCHOOL
JUNIOR HIGH SCHOOL
SENIOR HIGH SCHOOL
AIRPORT
QUIET SCHOOL
1
2
3
4
5
6
7
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11
12
N

TABLE-5. RESULTS OF SCHOOL NOISE INVESTIGATION

SCHOOL	DATE	ROOM NO	WINDOWS	WEATHER CONDITION	TAKE-OFF DIRECTION	NOISE LEVELS dBA		TIME (HR-MIN.) >60 dBA		TIME (HR-MIN.) 50-60 dBA	REMARKS
						MAX	MIN	AIR-CRAFT	TOTAL		
1	6-17-70	351	OPEN	CLEAR	NO.	98	<50	34M	34M	5HR	
	6-18	351	OPEN	CLEAR	SO.	>90	44	20M	20M	22M	
	6-19	301	OPEN	CLEAR	SO.	>90	48	15M	15M	29M	
	6-22	301	OPEN	CLEAR	NO.	>90	46	38M	38M	35M	
	6-23	PORT.	OPEN	CLEAR	NO.	>90	48	38M	38M	44M	
2	6-25	PORT.	CLOSED	CLEAR	NO.	81	46	19M	19M	29M	
	6-26	PORT.	OPEN	OVERCAST	NO.	>90	45	31M	31M	41M	
	6-29	3	CLOSED	OVERCAST RAIN	SO.	72	45	6M	6M	21M	
	6-30	3	OPEN	OVERCAST	SO.	80	44	12M	12M	26M	
3	7-6	101	CLOSED	CLEAR	SO.	60	45	0	0	4M	
	7-7	101	OPEN	CLEAR	NO.	82	46	30M	30M	44M	
	7-9	101	CLOSED	CLEAR	NO.	71	43	6M	6M	21M	
4	7-28	13	OPEN	CLEAR	SO.	72	43	3M	3M	40M	
	7-30	13	OPEN	CLEAR	NO.	80	42	26M	26M	64M	

TABLE-5. CONTINUED.

SCHOOL	DATE	ROOM NO.	WINDOWS	WEATHER CONDITION	TAKE-OFF DIRECTION	NOISE LEVELS dBA		TIME (HR-MIN.)			REMARKS
								>60 dBA		50-60 dBA	
						MAX.	MIN.	AIR-CRAFT	TOTAL		
5	7-21-70	K-1	OPEN	CLEAR	NO.	75	42	7M	8M	74M	HEAVY VEH. TRAFFIC
	8-3	K-1	OPEN		NO.	78	46	23M	24M	55M	HEAVY VEH. TRAFFIC
	8-4	22	CLOSED	CLEAR	SO.	63	51	1M	1M	6M	HEAVY VEH. TRAFFIC
	8-5	22	OPEN	CLEAR	NO./SO.	87	47	20M	103M	45M	HEAVY VEH. TRAFFIC
6	8-6	6	OPEN	CLEAR/OVERCAST	SO	84	47	32M	33M	50M	HEAVY TRUCK TRAFFIC
	8-7	6	OPEN	OVERCAST	SO.	86	46	43M	44M	55M	HEAVY TRUCK TRAFFIC
	8-10	6	OPEN	CLEAR	NO.	90	55	88M	33M	3M	HEAVY TRUCK TRAFFIC
	8-11	6	CLOSED	CLEAR	NO.	70	52	8M	8M	6M	HEAVY TRUCK TRAFFIC
7	8-12	14	OPEN	CLEAR	SO.	81	45	15M	15M	91M	
	8-13	16	OPEN	OVERCAST RAIN	SO./NO.	89	43	12M	15M	55M	
	8-14	9	CLOSED	CLEAR	NO.	60	41	0	0	10M	
	8-17	9	OPEN	CLEAR	SO.	90	42	28M	28M	36M	
8	8-19	18	OPEN	CLEAR	NO.	790	<40	13M	13M	27M	
	8-20	18	CLOSED	OVERCAST CLEAR	NO./SO.	79	<40	15M	15M	18M	
	8-21	D-16	OPEN	OVERCAST FOG	NO.	79	<40	6M	6M	23M	

TABLE-5. CONTINUED

SCHOOL	DATE	ROOM NO.	WINDOWS	WEATHER CONDITION	TAKE-OFF DIRECTION	NOISE LEVELS dBA		TIME (HR.-MIN.) >60 dBA		50-60 dBA	REMARKS
						MAX	MIN.	AIR-CRAFT	TOTAL		
9	8-24	9	OPEN	OVERCAST	SO.	90	<40	25M	25M	15M	
	8-25	MULT-18	OPEN	OVERCAST	SO.	80	<40	21M	21M	22M	
10	8-26	104	OPEN	CLEAR	NO.	82	<40	16M	16M	22M	
	8-27	104	OPEN	OVERCAST FOG	SO.	87	<40	20M	20M	22M	
	8-28	104	CLOSED	OVERCAST	SO./NO.	76	<40	15M	15M	23M	
	8-31	117	OPEN	OVERCAST	SO.	83	<40	23M	23M	21M	
11	9-1	19	OPEN	OVERCAST	SO.	84	<40	33M	33M	21M	
	9-2	19	CLOSED	CLEAR	SO.	75	<40	15M	15M	46M	
12		NURSE'S ROOM				62	49	0	0		QUIET SCHOOL

noise levels, the cost of sound attenuation may be prohibitive, such that the possibility of relocating these facilities should be considered. Furthermore, street traffic noise also presents a problem relating to speech interference, and noise from this source should also be included in any future school locations or noise control plans. Finally, in order to preclude the need for opening windows for ventilation, all of the schools should be provided with air conditioning.

It should also be mentioned that in the past, permanent hearing loss of children in these schools was not given serious consideration. It would appear, however, that under present conditions hearing damage could be a possibility.

SUMMARY

Aviation is still a fast growing industry. In 1960 only 16 airports serviced jets, while today over 400 airports receive jets. In 1960 there were some 224 commercial jet aircraft making approximately 26 million landings and take-offs. By 1973 there were almost ten times as many jet aircraft, approaching 100 million movements.

The problem of aircraft noise exists at every major airport in the world. Even if attempts to limit jet engine noise are successful, the problem will likely become more severe and, in all probability, jet engine noise will not be reduced to the point where the noise problem will be entirely eliminated from areas immediately adjacent to airports.

It is time we recognized that residential areas are not compatible with airport use. With the present and projected expansion of airport facilities as well as the projected increases in air traffic, the situation will undoubtedly become more acute in the next few years. In the meantime, a significant number of people suffer and will continue to suffer the ravages of aircraft noise. The solutions must be forthcoming before irreparable damage to these people takes place.