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Comparison of Noise Barrier Insertion-Loss Methodologies

WIN LINDEMAN

ABSTRACT

Field measurements were conducted before and after the construction of a noise barrier in St. Petersburg, Florida. These noise measurements were made to determine the effectiveness of the barrier by the use of a proposed standard methodology for determining insertion loss. Two methods were used: direct and indirect measured. A computer prediction was also conducted for comparative purposes. Close correlation was found between the two methods and the computer prediction. A recommendation was made to use the computer prediction technique in most instances and the direct method in those cases in which public interest in the barrier is high.

The objectives of the research study were (a) to provide the Florida Department of Transportation (FDOT) with information about the effectiveness of a noise barrier wall built along 54th Avenue South in St. Petersburg and (b) to provide the American National Standards (ANS) Working Group S12-6 with information on the effectiveness of their proposed Standard Method for Determining Insertion Loss of Outdoor Noise Barriers (1).

STUDY LOCATION

To achieve the objectives stated in the preceding paragraph, a before-and-after series of field measurements was planned to determine the insertion loss from the construction of a highway noise barrier wall. The site selected for the field measurements was located along 54th Avenue South in St. Petersburg, Florida. This state highway runs east and west and serves as the major access route to the beaches of southern Pinellas County (see Figure 1).

The existing level of roadway traffic is being increased as a result of an interchange with Interstate 275 as it progresses southward through St. Petersburg. The roadway is bordered on the north by a residential neighborhood known as Maximo Moorings between 37th Street South and 41st Street South. On the south side of this roadway is an open area where a city wastewater treatment plant and Eckerd College are located. The Maximo Moorings neighborhood was selected because of the impending construction of a noise barrier wall at this location and the availability of an existing roadway for before-and-after measurements. In addition, the availability of three vacant lots on which direct before-and-after measurements could be conducted and an equivalent site within 650 ft of the direct site location enhanced the desirability of this location for this type of study. The physical terrain is flat and, on first assessment, met all of the apparent requirements for the ANS study. The homes along the roadway are all single story, single family dwellings that have

FIGURE 1 Interchange area of Maximo Moorings and 54th Avenue South.

backyards facing 54th Avenue South. Profiles of the two measurement sites are shown in Figures 2 and 3.

BEFORE-AND-AFTER STUDIES

The before study was conducted on March 8, 1984, after an effort in February that was aborted when weather prohibited completion of any noise measurements. Two locations along 54th Avenue South were selected for the field measurements, as shown in Figure 1: Site 1 was selected as the direct-method location for the behind-the-wall study; at the same time, Site 2 was chosen as an equivalent site location. Selection of two sites would provide the working group with a comparison of two different field measurement techniques at one time.

Site 1, chosen because it was in the center of three vacant lots and had no activities, was monitored from two points: one was at a point equivalent to the edge of the future wall while the other was located behind the future barrier, 20 ft north of the first point and perpendicular to 54th Avenue South. The ground cover was grass and low weeds, typical of that found in this part of Florida, making Site 1 a soft site. This determination was borne out by comparison of the results of the field measurements and computer predictions. Several mature pines and other trees exist on the lots but were not located within the line of sight of the roadway. The measurement equipment was set up as a reference microphone (Microphone 1) and a receiver microphone (Microphone 2).

At Site 2, two microphones were set up in a backyard just east of the proposed barrier wall. This location was chosen for two reasons: the ground cover was also grass with no significant trees in the direct line of sight, and the traffic patterns were thought to be nearly identical to those found at Site 1, the direct measurement site. One variation between the sites was that the roadway narrowed from three lanes to two lanes between the two sites and that the Interstate off-ramp served as an earthen berm blocking traffic noise from the far lanes (east-

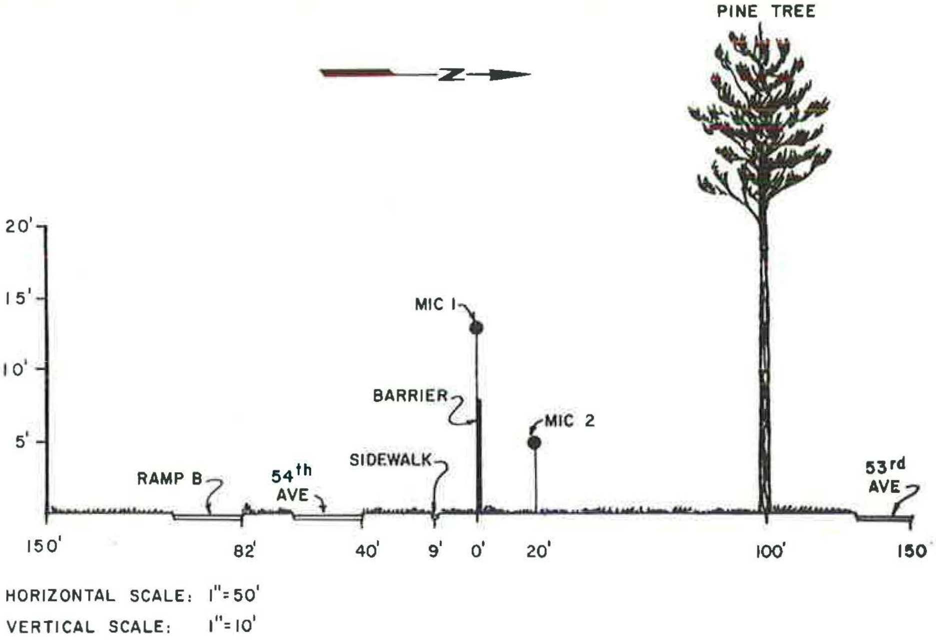

FIGURE 2 Profile of Site 1, showing location of Microphones 1 and 2.

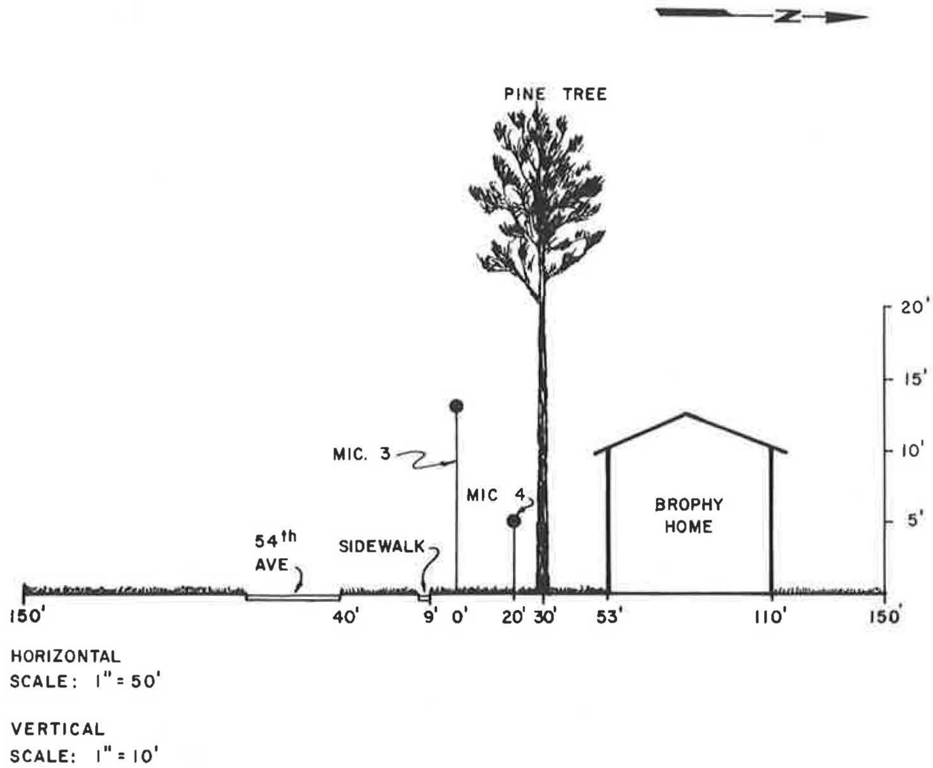

FIGURE 3 Profile of Site 2, showing location of Microphones 3 and 4.

bound). During field measurements, very little traffic was noted in the transition lane. The reference microphone, Microphone 3, was set up exactly in line with Microphone 1 at the same distance from the roadway.

Traffic counts were kept during each recording period, which lasted 20 min. The speeds were determined by using a radar gun that was calibrated before and after each study. The results of this effort are given in Table 1. Climatic conditions were automatically recorded. During the before studies, temperature varied from 60 to 68 °F while winds were steady at 5 mph out of the west-northwest to northwest direction; in the after study, temperature varied between 75 and 78 °F while winds were out of the west-northwest and northwest from 6 to 6 1/2 mph. The sky was clear during both studies.

At Microphones 2 and 3, the noise levels were recorded manually by the check-off method approved by FHWA, U.S. Department of Transportation (2). Each series of readings consisted of one reading taken every 10 sec until 100 readings were recorded. This produced an L10 level (within a 95 percent confidence level) that was converted to Leq, using all 100 readings, by a computer program developed for that purpose. Each sound level meter (SLM) was calibrated immediately before and after each run and the difference was noted.

At Microphones 1 and 4, the SLMs were set to record a continuous 20-min sample and then display

TABLE 1 Traffic Data for All Receivers on All Sites

	Westbound Traffic on 54th Avenue South					
	Cars		Medium Trucks		Heavy Trucks	
Run No.	No. of Vehicles	Speed (mph)	No. of Vehicles	Speed (mph)	No. of Vehicles	Speed (mph)
Before						
1	280	41	2	40	0	00
2	331	41	1	40	1	40
3	273	41	4	40	0	00
4	279	41	2	40	0	00
After						
1	342	39	11	35	3	35
2	264	40	4	30	7	32
3	250	39	5	38	5	32
4	253	41	9	36	5	35
5	224	40	8	37	7	37

Note: These data were recorded on Thursday, March 8, 1984, and Tuesday, April 24, 1984.

the Leq for the time period selected. It was the intention of the research team to conduct 4 runs at each location, but it soon became evident that this was not going to be feasible. On arrival at the measurement sites, which had been identified during the aborted February attempt, it was discovered that the contractor for the barrier wall installation was in the area and was preparing a base for the wall. This contractor was removing a small amount (generally less than 3 in.) of topsoil along the line of the wall by using a Gradall; this meant that the readings had to be delayed until the work was completed in the vicinity of the measurement locations. After completion of the base work in the vicinity of Site 1, a pair of noise measurements were taken. Site 2 could not be measured simultaneously because the Gradall had moved in front of that location and therefore dominated the noise levels at that point, even though it could no longer be detected at Site 1.

The ambient conditions for Runs 1 and 2 were determined to be the lowest actual reading during the monitoring period because this occurred in the absence of traffic in each case. (It is possible that the use of the L90 or an average of the lowest actual readings measured in the absence of traffic would make a more representative ambient determination.) By the time the first two runs had been made, the workers had completed their site preparation work and left the area. After their departure, another set of noise measurements was attempted at both sites and all four microphone locations. The results of the total effort can be found in Table 2.

Construction of the noise barrier wall was completed in March 1984 and the after condition measurements were scheduled to be made during the week of April 23. The precast concrete wall was 8 ft above ground level at most locations except at the far western end where a slight grade reduced the effective height to about 7 ft. The monitoring took place on a Tuesday with the sky completely free of clouds and a temperature of 78 °F. Because of man-power conditions and the experience of the previous measurement effort, the instrumentation was shifted around. Five runs were successfully completed on April 24, 1984, and the results are given in Table 3.

INSTRUMENTATION OF FOUR MICROPHONES

Throughout the studies, Microphone 1 instrumentation consisted of a General Radio (GR) Model 1988 Type 1 SLM with a 1/2-in. GR Model 1560-P42 microphone and preamplifier connected by a 30-ft cable. The microphone was mounted 13 ft in the air on a mast and topped with a windscreen. A GR Model 1562-A Sound Level Calibrator was used to calibrate the meter before and after each set of readings.

TABLE 2 Results of Noise Readings at Microphones 1 to 4 on All Runs

Microphone No.	Run No.	Time of Readings	Measured Leq (dBA)	Measured Ambient Leq (dBA)
1	1	4:55-5:15 p.m.	64.2	49
2	1	4:55-5:15 p.m.	58.2	49
1	2	5:23-5:43 p.m.	64.5	50
2	2	5:23-5:43 p.m.	59.1	50
1	3	6:00-6:20 p.m.	63.1	48
2	3	6:00-6:20 p.m.	57.7	48
3	3	6:00-6:20 p,m.	62.6	50
4	3	6:00-6:20 p.m.	–[a]	50
1	4	6:30-6:50 p.m.	–[a]	48
2	4	6:30-6:50 p.m.	58.8	48
3	4	6:30-6:50 p.m.	64.0	49
4	4	6:30-6:50 p.m.	–[a]	49

Note: These data were collected on March 8, 1984, at both sites.

[a] Data not collected due to equipment failure.

TABLE 3 Results of Noise Readings at Microphones 1 to 4 on Runs 1 to 5

Microphone No.	Run No.	Time of Readings	Measured Leq (dBA)	Measured Ambient Leq (dBA)
1	1	12:30-12:50 p.m.	65.4	53
2	1	12:30-12:50 p.m.	54.0	47
3	1	12:30-12:50 p.m.	66.7	53
4	1	12:30-12:50 p.m.	61.2	47
1	2	12:55-1:15 p.m.	67.1	51
2	2	12:55-1:15 p.m.	54.6	48
3	2	12:55-1:15 p.m.	72.2	51
4	2	12:55-1:15 p.m.	65.3	48
1	3	1:27-1:47 p.m.	65.5	51
2	3	1:27-1:47 p.m.	53.2	49
3	3	1:27-1:47 p.m.	66.1	51
4	3	1:27-1:47 p.m.	60.2	49
1	4	1:51-2:11 p.m.	65.9	49
2	4	1:51-2:11 p.m.	55.2	46
3	4	1:51-2:11 p.m.	68.8	49
4	4	1:51-2:11 p.m.	61.1	49
1	5	2:26-2:46 p.m.	66.9	51
2	5	2:26-2.46 p.m.	54.4	49
3	5	2:26-2:46 p.m.	67.4	51
4	5	2:26-2:46 p.m.	62.4	49

Note: These data were collected on April 24, 1984, at both sites.

Microphone 2 instrumentation during the before study consisted of a GR Model 1933 Type 1 SLM with a 1-in. GR Model 1961 microphone connected by a 10-ft cable. The microphone was topped with a windscreen and mounted on a tripod 5 ft above ground level. An LK Systems 10 audio timer was used to indicate the passage of 10 sec through a set of headphones and a GR Model 1567 SLM Calibrator was used to calibrate the system. In the after study, this system was replaced with one similar to Microphone 1 except that no cable was used and the microphone was maintained at 5 ft. In addition to the noise monitoring equipment, traffic data were gathered using radar and traffic counters while meterological data were gathered using a portable weather station located 20 ft west of Microphone 2 on a mast 13 ft high.

The equipment used at Microphone 3 in the before study consisted of a Bruel & Kjaer (B&K) Model 2209 Type 1 SLM with a 1-in. B&K Model 4145 microphone attached by a 10-ft cable. The microphone was mounted to a mast 13 ft aboveground and topped with a windscreen and a B&K Model 4230 SLM Calibrator was used to calibrate the system. In the after study, the system consisted of a GR Model 1933 Type 1 SLM and a 1-in. GR Model 1961 microphone attached to a 30 ft cable. A windscreen topped the microphone and the system was calibrated using a GR Model 1567 SLM Calibrator.

Microphone 4 was set back 20 ft north of Microphone 3 and in line with Microphone 2, which was the equivalent site receiver position; the equipment used varied in the before and after studies. The system used in the before study was identical to the system used at Microphone 2 in the after condition. The system used in the after study was similar to that used at Microphone 3 in the before study except that no cable was used and the height was maintained at 5 ft aboveground.

ACOUSTICAL DATA

Direct Method

The field measurements allowed for the analysis of the insertion loss by using the draft methodology developed by the working group. To compare the results effectively, each pair of appropriate receivers had to be matched to the proper data. Table 4 gives the adjusted source level information at the reference microphone (Microphone 1) at Site 1 in the before study. It should be noted that the source in Run 4 is not calculated; this resulted from battery failure midway through the run at this microphone. The results of the before study at Microphone 2, located 20 ft north of Microphone 1, are given in Table 5. This receiver (Microphone 2) was located in the behind-the-wall position for analysis by the direct measurement methodology. The after-barrier results at these two microphone locations are given in Tables 6 and 7. Table 8 gives the calculations for the insertion loss based on the direct method test. The mean adjusted insertion loss was determined to be 7.5 dBA.

Indirect Measured Method

The indirect measured method using an equivalent site was also employed to determine the mean insertion loss for the barrier. Table 9 gives the adjusted source level at the reference microphone (Microphone 3) during the before-wall condition. Table 10 shows that, because of a meter malfunction

TABLE 4 Adjusted Source Level Calculations at Site 1, Microphone 1—Before Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjust-ment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(B1)	(B2)	(B3)	(B4)= (B1-B3)	(B5)= (B2-B3)	(B6)= (B5-B4)	(B7)	(B8)= (B5+B7)
1	49	64.2	114 - 114=0	49	64.2	15.2	0	64.2
2	50	64.5	114 - 114=0	50	64.5	14.5	0	64.5
3	48	63.1	114 - 114=0	48	63.1	15.1	0	63.1
4	48	-	-	48	-	-	-	-

Note: Standard deviation = 0.8. These data were collected on March 8, 1984; the source was traffic noise from 54th Avenue South.

TABLE 5 Adjusted Source Level Calculations at Site 1, Microphone 2—Before Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjust-ment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(B1)	(B2)	(B3)	(B4)= (B1-B3)	(B5)= (B2-B3)	(B6)= (B5-B4)	(B7)	(B8)= (B5+B7)
1	49	58.2	114-114=0	49	58.2	9.2	-0.6	57.6
2	50	59.1	114-114=0	50	59.1	9.1	-0.6	58.5
3	48	57.7	114-114=0	48	57.7	9.7	-0.4	57.3
4	48	58.8	114-114=0	48	58.8	10.8	0.0	58.8

Note: Standard deviaton = 0.8. These data were collected on March 8, 1984; the source was traffic noise from 54th Avenue South.

TABLE 6 Adjusted Source Level Calculations at Site 1, Microphone 1—After Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(A1)	(A2)	(A3)	(A4)= (A1-A3)	(A5)= (A2-A3)	(A6)= (A5-A4)	(A7)	(A8)= (A5+A7)
1	53	65.4	114-114=0	53	65.4	12.4	0	65.4
2	51	67.1	114-114=0	51	67.1	16.1	0	67.1
3	51	65.5	114-114=0	51	65.5	14.5	0	65.5
4	49	65.9	114-114=0	49	65.9	16.9	0	65.9
5	51	66.9	114-114=0	51	66.9	15.9	0	66.9

Note: Standard deviation = 1.3. These data were collected on April 24, 1984; the source was traffic noise from 54th Avenue South.

TABLE 7 Adjusted Source Level Calculations at Site 1, Microphone 2—After Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(A1)	(A2)	(A3)	(A4)= (A1-A3)	(A5)= (A2-A3)	(A6)= (A5-A4)	(A7)	(A8)= (A5+A7)
1	47	54.0	114-114=0	47	54.0	7.0	-1.0	53.0
2	48	54.6	114-114=0	48	54.6	6.6	-1.0	53.6
3	49	53.2	114-114=0	49	53.2	4.2	-2.2	51.0
4	46	55.2	114-114=0	46	55.2	9.2	-0.6	54.6
5	49	54.4	114-114=0	49	54.4	5.5	-1.7	52.7

Note: Standard deviation = 1.2. These data were collected on April 24, 1984; the source was traffic noise from 54th Avenue South.

TABLE 8 Calculations for Insertion Loss Based on Direct Method Test at Site 1

	BEFORE 3/8/84			AFTER 4/24/84			
Run #	Adjusted Source Level at Reference ence (1) MIC 1	Adjusted Source Level at Receiver (2) MIC 2	Before Difference (3)= (1-2)	Adjusted Source Level at Reference (4) MIC 1	Adjusted Source Level at Receiver (5) MIC 2	After Difference (6)= (4-5)	Insertion Loss=Before Difference - After Difference (7)=(6-3)
1	64.2	57.6	6.6	65.4	53.0	12.4	6.2
2	64.5	58.5	6.0	67.1	53.6	13.5	7.5
3	63.1	57.3	5.8	65.5	51.0	14.5	8.7
4	-	58.8	-	65.9	54.6	11.3	-
5	-		-	66.9	52.7	14.2	-

Note: For before study, standard deviation = 0.2; for after study, standard deviation = 1.2; $\overline{IL}$ = 7.5.

TABLE 9 Adjusted Source Level Calculations at Site 2, Microphone 3—Before Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(B1)	(B2)	(B3)	(B4)= (B1-B3)	(B5)= (B2-B3)	(B6)= (B5-B4)	(B7)	(B8)= (B5+B7)
1								
2								
3	50	62.6	94-94 = 0	50	62.6	12.6	0.0	62.6
4	49	64.0	94-94 = 0	49	64.0	15.0	0.0	64.0

Note: Standard deviation = 0.5. These data were collected on March 8, 1984; the source was traffic noise from 54th Avenue South.

TABLE 10 Adjusted Source Level Calculations at Site 2, Microphone 4—Before Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(B1)	(B2)	(B3)	(B4)= (B1-B3)	(B5)= (B2-B3)	(B6)= (B5-B4)	(B7)	(B8)= (B5+B7)
1								
2								
3	50	a						
4	49	a						

Note: These data were collected on March 8, 1984; the source was traffic from 54th Avenue South.

[a] Data lost due to malfunction of the Leq Meter.

TABLE 11 Adjusted Source Level Calculations at Site 2, Microphone 3—After Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(A1)	(A2)	(A3)	(A4)= (A1-A3)	(A5)= (A2-A3)	(A6)= (A5-A4)	(A7)	(A8)= (A5+A7)
1	53	66.7	114-114=0	53	66.7	13.7	0	66.7
2	51	72.2	114-114=0	51	72.2	21.2	0	72.2
3	51	66.1	114-114=0	51	66.1	15.1	0	66.1
4	49	68.8	114-114=0	49	68.8	19.8	0	68.8
5	51	67.4	114-114=0	51	67.4	16.4	0	67.4

Note: Standard deviation = 1.3. These data were collected on April 24, 1984; the source was traffic from 54th Avenue South.

that went undetected during the sampling periods, no data were obtained at the receiver position (Microphone 4) during the before-wall testing. After the wall was constructed, the site was once again studied at Microphones 3 and 4; the results of this study are given in Tables 11 and 12. To determine the mean insertion loss by the equivalent site method, a comparison of the after conditions at Microphones 3 and 4 must be made. At the same time, a comparison of Microphones 1 and 2 needs to be made to determine if anything unusual appears to have occurred between the two reference locations. Table 13 gives a comparison of results of Microphones 3 and 4 and also shows the mean insertion loss determination for the barrier based on the difference between Microphones 3 and 4 and Microphones 1 and 2. The mean insertion

TABLE 12 Adjusted Source Level Calculations at Site 2, Microphone 4—After Study

Run	Measured Levels		Calibration Adjustment = (End-Start)/2	Levels Adjusted for Calibration		Source Level - Ambient Level	Ambient Adjustment	Adjusted Source Level at the Receiver
	Ambient	Source		Ambient	Source			
	(A1)	(A2)	(A3)	(A4)= (A1-A3)	(A5)= (A2-A3)	(A6)= (A5-A4)	(A7)	(A8)= (A5+A7)
1	47	61.2	94-94 = 0	47	61.2	14.2	0	61.2
2	48	65.3	94-94 = 0	48	65.3	17.3	0	65.3
3	49	60.2	94-94 = 0	49	60.2	11.2	0	60.2
4	46	61.1	94-94 = 0	46	61.1	15.1	0	61.1
5	49	62.4	94-94 = 0	49	62.4	13.4	0	62.4

Note: Standard deviation = 1.2. These data were collected on April 24, 1984; the source was traffic from 54th Avenue South.

TABLE 13 Calculations Based on Indirect Measured Method

	AFTER 4/24/84			AFTER 4/24/84			
Run #	Adjusted Source Level at Reference ence (1) MIC 3	Adjusted Source Level at Receiver (2) MIC 4	Difference (3)= (1-2)	Adjusted Source Level at Reference (4) MIC 1	Adjusted Source Level at Receiver (5) MIC 2	Difference (6)= (4-5)	Insertion Loss (7)=(6-3)
1	66.7	61.2	5.5	65.4	53.0	12.4	6.9
2	72.2	65.3	6.9	67.1	53.6	13.5	6.6
3	66.1	60.2	5.9	65.5	51.0	14.5	8.6
4	68.8	60.2	7.7	65.9	54.6	11.3	3.6
5	67.4	62.4	5.0	66.9	52.7	14.2	9.2

Note: For columns (1), (2), and (3), standard deviation = 1.0; for columns (4), (5), and (6), standard deviation = 1.2; $\overline{IL}$ = 7.0.

loss determined by using this method was 7.0 dBA compared with 7.5 dBA determined by using the direct method.

Analysis of the data from Microphones 1 and 3 indicates that the traffic characteristics were not as similar as originally presumed, especially during the after-wall study. It is difficult to explain this difference except to note that in several instances at Site 2 heavy trucks passed by in an acceleration mode and set unusually high measured peaks that skewed the Leq at this location. By the time these trucks reached Site 1, some 650 ft down

TABLE 14 STAMINA 2.0 Prediction Results

	Before Leq			After Leq		
Run	Measured	Predicted	Difference	Measured	Predicted	Difference
Microphone 1						
1	64.2	63.9	0.3	65.4	65.8	0.4
2	64.5	65.0	0.5	67.1	65.6	1.5
3	63.1	64.1	1.0	65.5	65.1	0.4
4				65.9	65.9	0.0
5				66.9	66.2	0.7
Standard Deviation			0.3			0.4
Microphone 2						
1	58.2	61.9	3.7	54.0	56.9	2.9
2	59.1	62.9	3.8	54.6	57.4	2.8
3	57.7	62.1	4.4	53.2	56.6	3.4
4	58.8	61.8	3.0	55.2	57.4	2.2
5				54.4	58.1	3.7
Standard Deviation			0.5			0.5
Microphone 3						
1				66.7	65.8	0.9
2				72.2	65.6	6.6
3	62.6	64.1	1.5	66.1	65.1	1.0
4	64.0	63.8	0.2	68.8	65.9	2.9
5				67.4	66.2	1.2
Standard Deviation			0.7			2.2
Microphone 4						
1				61.2	63.4	2.2
2				65.3	63.3	2.0
3				60.2	62.7	2.5
4				61.1	63.6	2.5
5				62.4	63.9	1.5
Standard Deviation						0.4

Note: Blank space indicates lack of data.

the road, they apparently were not in this strong acceleration mode. A variation in the volume of trucks (heavy and medium) was also noted between the before study and the after study. It should be noted that the bias for the two methods was found to be identical.

Computer Prediction

For comparative purposes, the field data were loaded into the STAMINA 2.0 computer prediction program. A validation of the before-and-after field measurements was made at all four microphone locations. Computer prediction results are given in Table 14; these results were generated by using the traffic data given in Table 1. Table 15 gives the results of the insertion loss based on a computer prediction using the STAMINA 2.0 program. The mean insertion loss is shown to be 6.1 dBA.

TABLE 15 Results of Mean Insertion Loss Determined by Using STAMINA 2.0 Computer Prediction Program

Run No.	Without Barrier	With Barrier	Difference
1	63.4	56.9	6.5
2	63.3	57.4	5.9
3	62.7	56.6	6.1
4	63.6	57.4	6.2
5	63.9	58.1	5.8

Note: Without barrier, mean = 63.4; with barrier, mean = 57.3; mean insertion loss = 6.1.

RESULTS

A comparison of the mean insertion loss as determined by the computer prediction program was made with the results of the two draft methodologies. Based on the results, there appears to be a mean difference of 0.9 dBA between the results of using the indirect measured method and the computer predictions. As noted earlier, the difference between the direct and indirect measured methods could probably be explained based on the apparent difference in the source strength between the two points and the change in total truck volume; the acceleration of heavy trucks was isolated as the probable cause of this phenomenon. The difference between the computer predictions and the results of using the direct method is not easy to isolate. It would appear that the truck volume may be the cause of the difference, but it is difficult to conclude this with any degree of certainty.

SUMMARY AND RECOMMENDATIONS

In summation, the methodologies found in the draft standard (direct and indirect measured) are all usable; however, from the standpoint of traffic noise and highway agencies, use of computer predictions is recommended. This recommendation is based on manpower requirements, equipment needs, and relative accuracy of the various methods compared to the accuracy needs of the agency. Use of the indirect measured method is strongly discouraged because of the vast number of variables that can occur that are difficult to quantify. Although not employed during this research effort, the indirect predicted method would appear to be preferable to the indirect measured method. Using the direct method is suggested for those locations where public involvement has been high and the possibility of controversy has surfaced. This method would give greater credence to the ability of the barrier owner to accurately anticipate barrier effectiveness.

REFERENCES

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Airport Noise Monitoring Systems in North America

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ABSTRACT

Airport noise is a recognized by-product of a transportation-based economy. Because the number of airports, aircraft, and flight operations over adjacent airport communities are essential to the economic base, noise monitoring systems are being installed by airport proprietors. Currently, there are 25 systems in operation at airports in North America (two additional airports are in the process of bidding on and installation of noise monitoring systems). They have been installed for a variety of reasons and purposes, including compliance with enacted regulations or standards. These airport noise systems consist of four basic components: remote monitoring station, central processing station, software, and accessories. It is anticipated that the number of such systems will increase more rapidly in the future, partially due to available federal funding under Federal Aviation Regulations (FAR) Part 150: Airport Noise and Land Use Planning.

Air transportation is a major component of the national transportation system. The Federal Aviation Administration (FAA), U.S. Department of Transportation, estimates that there are nearly 15,000 airports (towered and nontowered) in the United States. These airports operate civil air fleets of approximately 195,000 aircraft throughout the United States, generating nearly 8 million flight operations annually.

Although aircraft operations are beneficial to the economic base of the United States, there are certain impacts associated with such operations. Due to the rapid growth of airports and the adjacent airport communities, along with increasing numbers of jet-engined aircraft that operate during a 24-hr period, potential noise impact conditions often exist in residential areas near airports.

Many techniques are being used to address this potential problem through source controls (i.e., engine noise suppression, new generation aircraft) as well as receiver controls (i.e., building codes, land using planning) at the federal level, primarily through the FAA. Such noise-related FAA activities include Federal Aviation Regulations (FAR) Part 36: Noise Certification, FAR Part 91: General Operations and Flight Rules, and FAR Part 150: Airport Noise and Land Use Planning (1). Some state and municipal governments are also taking certain steps to control airport-related noise by using the regulatory and planning process (2-4). An increasingly common approach as part of the overall management of airport noise is the establishment of a permanent airport noise monitoring system.

HISTORY

The acoustical monitoring of airport noise on a permanent and continuous basis is a relatively new phenomenon in the United States. Historically, the first such system was installed by the Port Authority of New York in 1967, and was used initially at John F. Kennedy International Airport (5). Similar systems