FIELD PERFORMANCE OF PARALLEL BARRIERS

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ABSTRACT

The behaviour of single highway noise barriers is fairly well understood, but little attention has been given to possible interactions when two barriers are built parallel to each other. A series of measurements on two barriers along Highway 417 suggest that the effects of any interactions are small if they exist at all.

SOMMAIRE

On comprend déjà très bien le comportement des écrans anti-bruit isolés installés en bordure des autoroutes. Toutefois, peu d'études ont été entreprises dans le but de comprendre l'interaction de deux écrans de ce genre placés en parallèle. Une série de mesures portant sur deux écrans anti-bruit installés le long de l'autoroute 417 porte à croire que si une telle interaction existe, elle est faible.

INTRODUCTION

The field performance of highway noise barriers has been studied extensively in the past few years. These studies usually have involved measurement of the performance of a single barrier parallel to one side of a roadway, with little or no interest being given to the situation where barriers are present on both sides of the roadway. It has been suggested by some workers[1,2] that this latter configuration can result in degradation of the barrier performance due to a reverberant build up of sound, in some cases producing a net increase in noise level behind the barriers. There is also evidence from other workers[3] indicating that there is no interaction between the barriers, and that the two barriers may be treated as being independent.

The proposed construction of two noise barriers, one on each side of Highway 417 in Ottawa, between Woodroffe and Maitland Avenues, provided an opportunity to test the performance of this configuration.

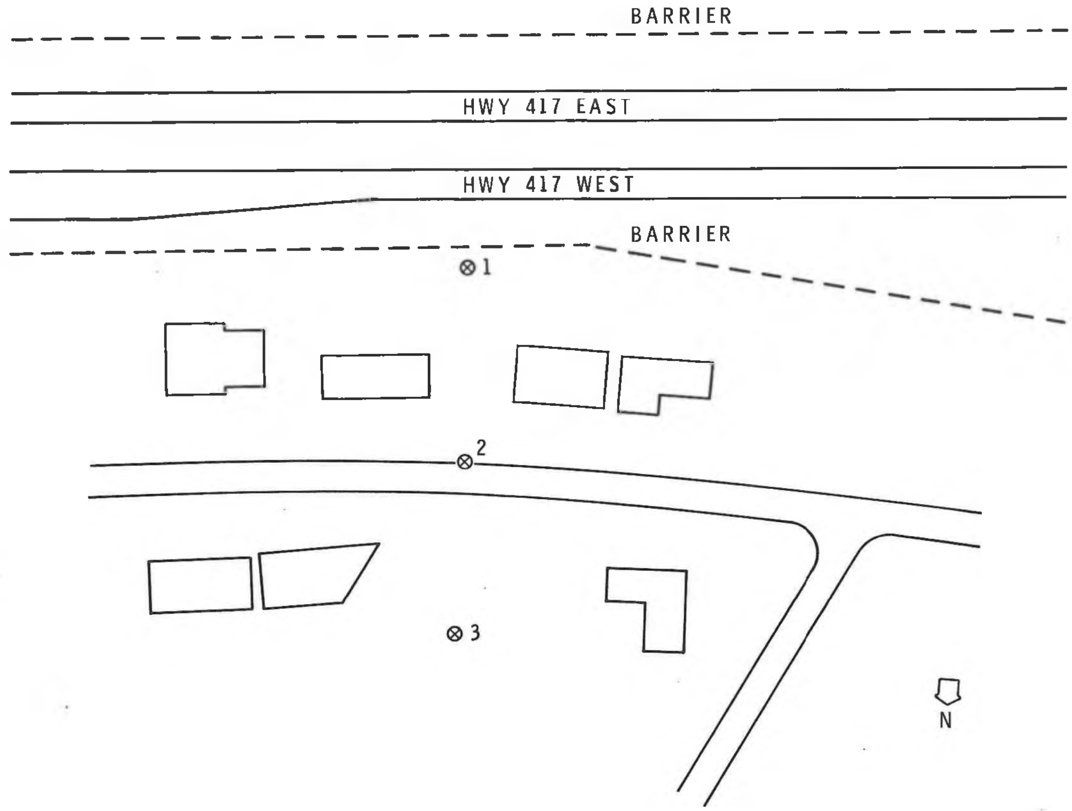

FIGURE 1
SITE 1

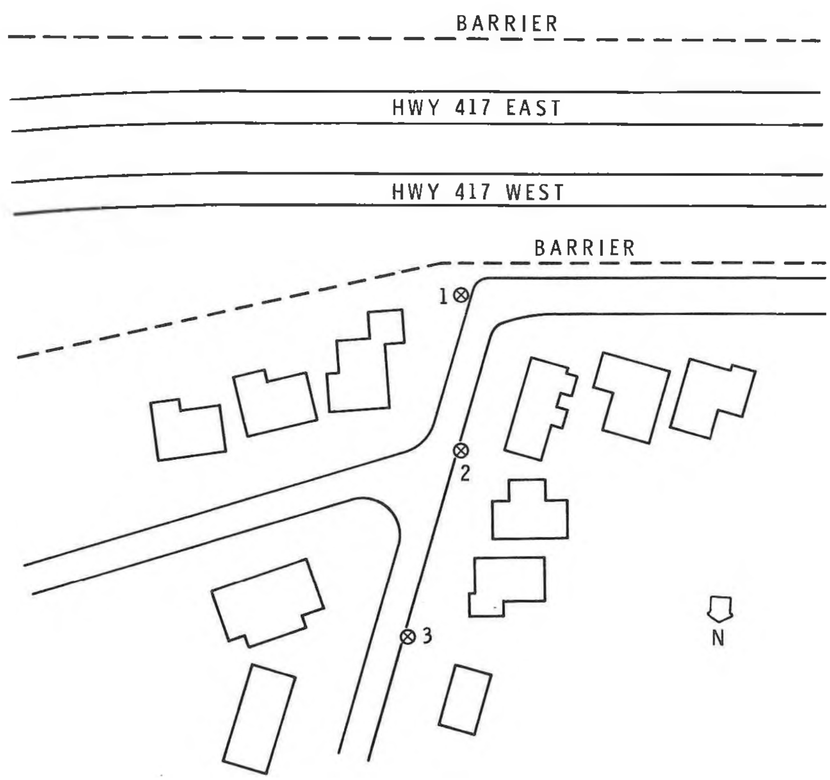

FIGURE 2
SITE 2

MEASUREMENT LOCATIONS

Measurements were made at six locations, three on the north and three on the south sides of Highway 417.

The three sites on the north side are shown in Figs. 1, 2, and 3. There was no barrier constructed on the south side of Highway 417 at Site 3.

Figure 4 shows Sites 4 and 5 which were on the south side of the highway. The third site on the south side, Site 6, was an open playing field on the opposite side of the highway to Site 3 with no barrier between it and the south side of the highway. Since there was a barrier on the north side measurements at Site 6 could possibly have been affected by sound reflected from it.

At each site, ten or more microphones were arrayed on three masts which extended to 7.6 m. The first mast was placed as close as possible to the right-of-way fence, the second was located approximately 50 m behind the first, and the third approximately 50 m behind the second. The most distant mast was thus about 100 m from the fence. The most pronounced effect of parallel barriers is expected at distances in excess of 100 m,[2] however it was found that the ambient noise in the neighbourhood made meaningful measurement of the highway traffic noise impossible at such distances.

MEASUREMENT PROCEDURE

Measurements were made using Metrosonics dB 301/14 data loggers that take four sound level readings each second and calculate the equivalent sound level each minute. The one-minute equivalent levels are stored internally for later readout. Equivalent levels for 15-minute periods were calculated as energy averages of 15 consecutive one-minute equivalent levels. Data were collected for three or four 15-minute periods during which traffic counts were taken to permit a check with prediction models.

Measurements were made in three phases. Phase 1 measurements were made before any construction began to determine the noise environment before the noise barrier were erected. These measurements were made during off-peak hours on weekdays and traffic counts showed there to be a fairly consistent 1600 vehicles per hour travelling in each direction, of which about 10 per cent were heavy vehicles.

Phase 2 measurements were made after the erection of the barrier along the north side of the highway, and Phase 3 measurements were made after the erection of the second barrier along the south side. Care was taken to place the microphones as close as possible to the same positions for all three phases of the measurements.

Unfortunately, the Phase 2 and Phase 3 measurements had to be made on weekends because of equipment and manpower limitations. The traffic volume was found to be very nearly the same as on weekdays, but the percentage of heavy vehicles was down sharply from 10 to 1 - 2 per cent. The ambient level in the neighbourhood caused by local traffic, children playing, lawn mowers, etc. would also be expected to be higher

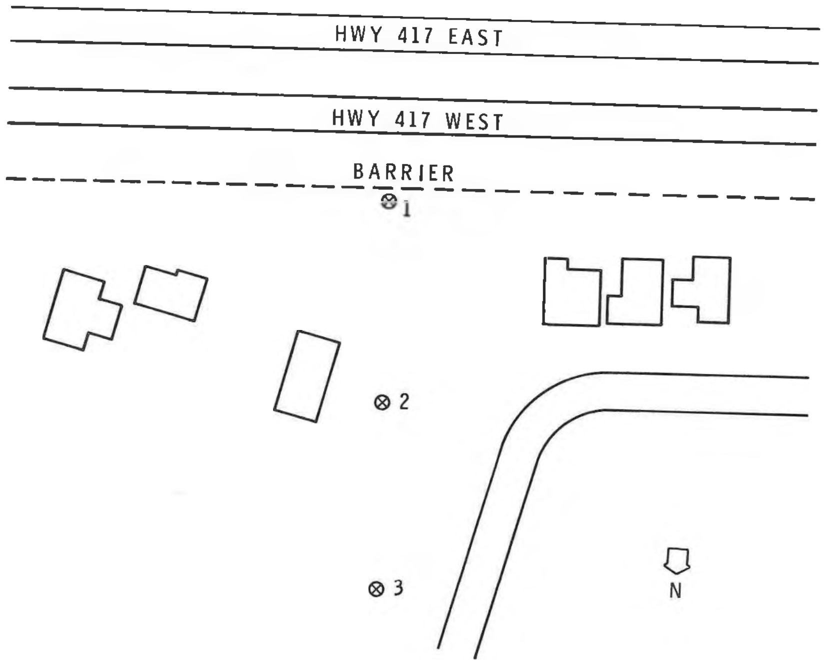

FIGURE 3
SITE 3

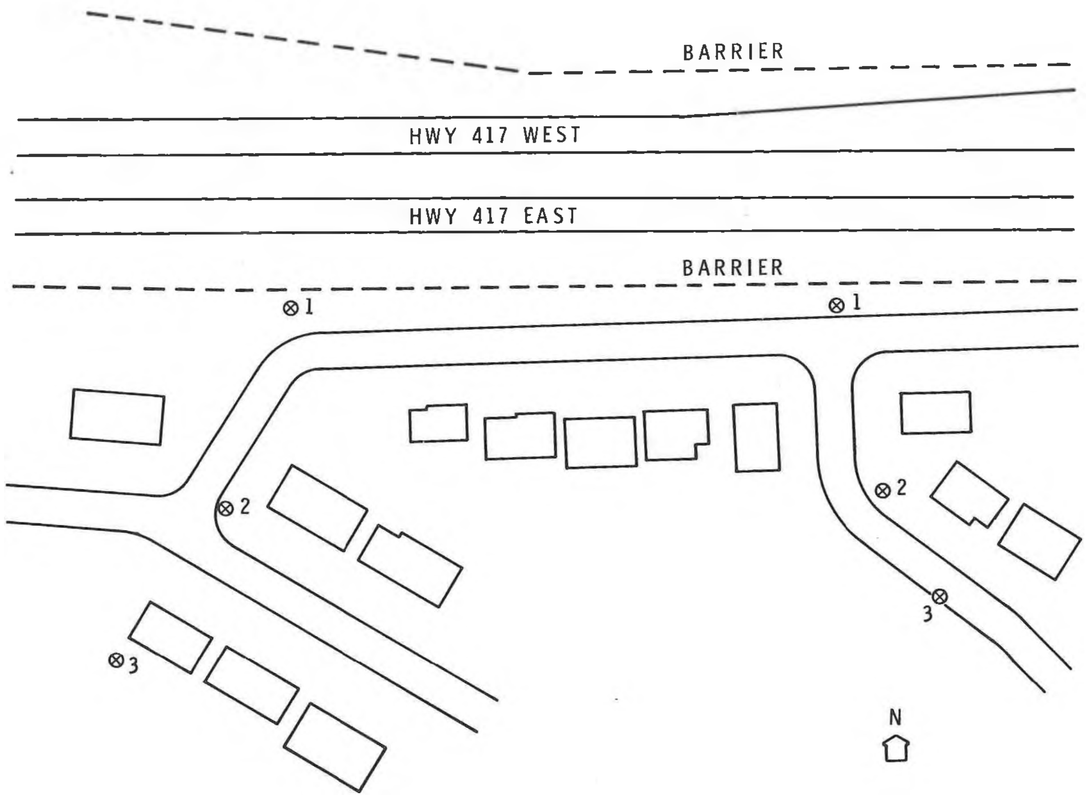

FIGURE 4
SITES 4 AND 5

on weekends. This means that measurements made at the mast furthest from the highway are somewhat less reliable. The time available for the Phase 2 measurements was very short because of the construction schedule so some of the measurements were made under less than ideal conditions.

DISCUSSION OF RESULTS

At each measurement site a microphone was placed at the top of the first mast to provide a reference microphone that would be unaffected by the erection of a barrier on the same side of the roadway as the site. The level measured at this microphone is affected by sound reflected from a barrier erected on the opposite side of the roadway. However this change can be determined by comparing measured levels with those calculated from traffic counts. The differences between the level at the reference microphone and the levels at the other microphones, averaged over the three or four measurement periods, are given in Tables 1 to 6 for the six sites. Also given in the tables are the average level measured at the reference microphone and the level predicted on the basis of the traffic counts using the National Research Council of Canada traffic noise prediction model.(4) The following is a detailed discussion of the results from each site.

Measurements on the North Side of the Highway

Site 1 The Phase 2 measurements given in Table 1 show an increase in attenuation consistent with the erection of a barrier between the highway and the microphones.

The Phase 3 measurements do not show any clear change in attenuations measured at this site. Compared with the Phase 1 measurement, there appears to be a 1 dB increase at the reference microphone, although a change of this magnitude is within the measurement uncertainty of 1 dB. The apparent increase in attenuation at the second mast (microphones 5 to 8) is more likely due to a change in the percentage of heavy vehicles, however traffic counts are not available for the Phase 2 measurement so this cannot be verified.

Site 2 The Phase 2 measurements, given in Table 2 show an increase in attenuation consistent with the erection of a barrier between the highway and the microphone.

The Phase 3 measurements indicate that there is an increase in level at the upper microphones relative to the Phase 2 measurements, although there is still a net attenuation relative to Phase 1. This may be due to the erection of the second barrier.

Site 3 This site is behind the barrier on the north side of the highway but beyond the end of the southern barrier. The Phase 2 measurements given in Table 3 indicate that the barrier is behaving normally. The noise levels at the back mast were unchanged at 57 dBA which is not an unusual level for a suburban site during the daytime. The highway traffic was audible, but was not the dominant noise source.

Measurements on the South Side of the Highway

Site 4 The Phase 2 measurements given in Table 4 show that there was an increase in noise level after the erection of the barrier on the north side of the highway. However, the measurements were made on a fairly windy day with the wind blowing in the direction of propagation. This would result in higher noise levels at the more distant microphones. The rapid construction of the second barrier prevented a repeat of these measurements.

The Phase 3 measurements indicate that the barrier is effective in attenuating the noise at all of the measurement positions. It should be pointed out that the levels at the back mast for the Phase 3 measurements were dominated by the local ambient level rather than the highway and that nearby construction equipment may have raised the local ambient levels during the Phase 1 measurements.

Site 5 The Phase 2 measurements given in Table 5 were made on the same day as those at Site 4, thus the comments regarding the wind are equally applicable. A second complicating factor was that the back mast was in the rear yard of a house and partially shielded from the road. As a result the levels measured at microphones 10, 11 and 12 were dominated by local noises and cannot be considered reliable. On the basis of these considerations it is believed that the apparent increase in levels are an artifact of the measurement conditions.

The Phase 3 measurements show the levels at the back two masts to be between 55 and 60 dBA. These are typical of a suburban environment and are indicative of local noise sources, although the highway traffic is still audible. These measurements do not provide a valid estimate of the attenuation provided by the barrier.

Site 6 This site consisted of a large level grass-covered field with no nearby reflecting surfaces and should have provided a good test of the effect of reflections from a barrier on the opposite side of the road. The data given in Table 6 certainly show an increase in the relative levels, but they also show that the level measurements at the reference microphone are much lower than expected. This is the result of this section of the highway being repaved between the two measurements. The old concrete surface was replaced with a coarse aggregate asphalt which resulted in a substantial reduction in the tire noise and a change in the spectral balance of the noise.

The Phase 2 measurements show an increase in level close to the ground relative to several metres above at both of the more distant masts. There are three factors that may have influenced the measurements; the barrier on the north side of the road, the reduced fraction of heavy vehicles, and the new pavement which both changes the spectral balance and raises the effective source height. These complications make it difficult to determine the exact cause of the observed changes in relative level.

CONCLUSIONS

This series of measurements clearly point out at least two of the problems inherent in the measurement of outdoor noise propagation in a suburban situation. It is often not possible to make measurements under ideal weather conditions and if the conditions are poor there is no reliable means of estimating the effect that may have on the measured levels. Noise measurements in a subdivision, particularly those made on a weekend, are invariably contaminated by the sounds of children playing, lawn mowers and local traffic. Levels of 50 to 55 dBA, such as were found at the rear masts at most of the sites, are normal in a suburban setting, thus it is apparent that measurements made at these locations are more indicative of the local noise environment than they are of noise emanating from the highway and thus should not be used as a reliable measure of the barrier performance.

On the basis of the measurements reported here, there is no clear evidence that building a second barrier parallel to an existing one will degrade the performance of the original barrier. Nor is there clear evidence that a barrier can cause an increase in the noise level on the unprotected side of the road.

It is possible that there are real effects associated with the second barrier, however they cannot be considered important in most practical situations as the traffic noise is soon masked by local noise sources as the distance behind the barrier is increased.

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REFERENCES

(1) Simpson, M.A., "Noise Barrier Design Handbook." Report No. FHWA-RD-76-58, prepared by Bolt Beranek and Newman Inc., Arlington, VA 22209, USA (1976).

(2) Hajek, J.J. and Kwan, L., Proceedinngs INTER-NOISE 80, Vol. 2, p. 595 (1980).

(3) Nelson, P.M., Abbott, P.G., and Salvidge, A.C., "Acoustic Performance of the M6 Noise Barriers." Transport and Road Research Laboratory Report 731, Growthorne, Berkshire, U.K. (1976).

(4) Halliwell, R.E. and Quirt, J.D., "Traffic Noise Prediction." National Research Council of Canada, Division of Building Research, Building Research Note No. 146 (1980).

TABLE 1

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-3	-13	-
2	2.9	-1	-13	-12
3	4.1	-.5	-10	-11
4 ref.	7.6	0	0	0
Mast 2				
5	1.6	-15	-	-17
6	2.9	-13	-16	-
7	5.3	-12	-16	-18
8	7.6	-10	-14	-15
Mast 3				
10	4.1	-18	-19	-19
11	6.4	-17	-18	-
12	7.6	-16	-17	-16
Measured level at reference		74	73	71
Predicted level at reference		75	-	73

SITE NO. 1, north side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 2

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-2	-14	-
2	2.9	0	-13	-13
3 ref.	7.6	0	0	0
Mast 2				
4	1.6	-10.5	-16	-18
5	4.6	-10.5	-19	-17
6	6.4	-9	-17	-12
Mast 3				
7	1.6	-18	-21	-
8	2.9	-17	-21	-21
9	5.3	-16	-20.5	-18
10	7.6	-15	-19.5	-17
Measured level at reference		74	72	72
Predicted level at reference		76		74

SITE NO. 2, north side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 3

Microphone Number		Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)
Mast 1				
	1	1.6	-3	-12
	3	4.1	0	-7
	4 ref.	7.6	0	0
Mast 2				
	5	1.6	-13	-13
	6	2.9	-11	-12
	7	5.3	-10	-12
Mast 3				
	10	4.1	-16	-15
	11	6.4	-14	-15
	12	7.6	-14	-14
Measured level at reference			73	72
Predicted level at reference			75	74

SITE NO. 3, north side of Highway 417

Average Level at Each Microphone Relative To Reference at Top of Front Mast

TABLE 4

Microphone Number		Height (m)	Sound Pressure Level Relative To Reference Microphone (dB): Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1					
	1	1.6	-3	-2	-
	2	2.9	-1	0	-11
	3	4.1	-	-1	-6
	4 ref.	7.6	-0	0	0
Mast 2					
	6	2.9	-10	-9	-17.5
	7	5.3	-8	-7	-16
	8	7.6	-6	-5	-12.5
Mast 3					
	10	4.1	-16.5	-9	-
	11	6.4	-13.5	-11	-17.5
	12	7.6	-13	-10	-17
Measured level at reference			75	74	73
Predicted level at reference			75	74	73

SITE NO. 4, south side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 5

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)	Phase 3 (2 barriers)
Mast 1				
1	1.6	-1	-1	-
2	2.9	-3	0	-10
3	4.1	-2	0	-4
4 ref.	7.6	0	0	0
Mast 2				
5	1.6	-15	-	-16
6	2.9	-13	-10	-14
7	5.3	-11	-8	-11
8	7.6	-9	-7	-
Mast 3				
10	4.1	-21	-12	-
11	6.4	-18	-13	-16
12	7.6	-17	-12	-15
Measured level at reference		74	73	71
Predicted level at reference		75	75	72

SITE NO. 5, south side of Highway 417

Average Level at Each Microphone Relative to Reference at Top of Front Mast

TABLE 6

Microphone Number	Height (m)	Sound Pressure Level Relative To Reference Microphone (dB) Phase 1 (no barriers)	Phase 2 (1 barrier)
Mast 1			
1	1.6	-3	-3
2	2.9	-1	-2
4 ref.	7.6	0	0
Mast 2			
5	1.6	-13	-6
6	2.9	-11	-5
7	5.3	-4	-4
Mast 3			
10	4.1	-12	-6
11	6.4	-9	-5
12	7.6	-8.5	-5
Measured level at reference		75	70
Predicted level at reference		77	75

SITE NO. 6, south side of Highway 417

Average Level at Each Microphone Relative To Reference at Top of Front Mast

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