FINAL REPORT

EVALUATION OF ARMCO SOUND BARRIERS ON TWO BRIDGES ON I-495

by

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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ABSTRACT

The purpose of this study was to determine the effectiveness of ARMCO double-wall, steel noise barriers attached to bridge parapets so as to provide continuity for roadside barriers. Measurements were taken opposite the sites of the discontinuities on two bridges before and after the gaps were filled. The measurements were recorded in both the analog and digital modes using the technique described in reference 2 of this report.

It was concluded that the bridge barriers significantly contributed to lessening the impact of traffic noise on the adjacent communities. It was also concluded that the expansion joints used in the bridge decks created an annoying noise when crossed by traffic, and that such noise should be ameliorated where it occurs.

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When the Virginia Department of Highways and Transportation planned to construct extensive noise barriers along I-495 in Fairfax County, it also had to consider what treatment to apply at those sites where I-495 bridged local roadways or railroads. At such locations, the roadside berms and barriers would be breeched, thus permitting the leakage of noise around the ends of the barriers and into the adjacent communities.

The principal construction project involved the addition of four lanes to I-495. Because the roadway had to be widened, the parapets on the bridges had to be removed to permit widening of the decks. The new parapets were designed to hold ARMCO double-wall, steel noise barriers. Because there was no direct confirmation of the effectiveness of short barrier segments added in this manner, a study was planned in which direct measurements were to be made before and after the addition of the bridge barriers.(1) Two bridges were chosen for study; one across Heming Avenue and the other over the main line of the Southern Railroad.

PURPOSE

The purpose of the study was to evaluate the effectiveness of the ARMCO noise barriers installed on bridge parapets.

PLANNING AND PROCEDURES

Much of the preparation and methodology for the study was the same as that used for an earlier study of neighborhood noise conducted in the same area. Thus, for details of the methods used, the reader is directed to references 2 and 3. The principal differences in procedure between the two studies were as follows:

1. Measurements in the bridge study were much shorter, initially 30 minutes but only 15 minutes for the later measurements.

2. Because of the short time durations, transmission cables were laid on the ground rather than being strung on utility cables.

3. Because line current was not available at the railroad bridge site, an alternative power source consisting of standard 12-volt automoble storage cells feeding a dc/ac converter was used there.

4. Only the immediate vicinities of the two bridges were covered in the study. A complete set of measurements at all of the neighborhood locations would have been excessively costly and would have been of limited usefulness to the evaluation of the bridge barrier, because all but two of the neighborhood locations were either far or shielded from the bridge by housing and terrain.

SITE DESCRIPTIONS

At site number 1, I-495 bridges Heming Avenue (see Figure 1), which is part of an inter-neighborhood thoroughfare. There is single-family housing on both sides of Heming Avenue, but the closest house to the interstate is 67 m. (220 ft.) south of it and on the west side of the avenue. As can be seen in Figure 1, the measurements were taken alongside the sidewalk that runs parallel to the east side of Heming Avenue. The ground rises away from the avenue on both sides for a distance of 45.7 m. (150 ft.) from I-495. At measurement locations 17 and 18 the ground rises only on the west side of the avenue. Except for a narrow strip of grass between the sidewalk and the avenue,

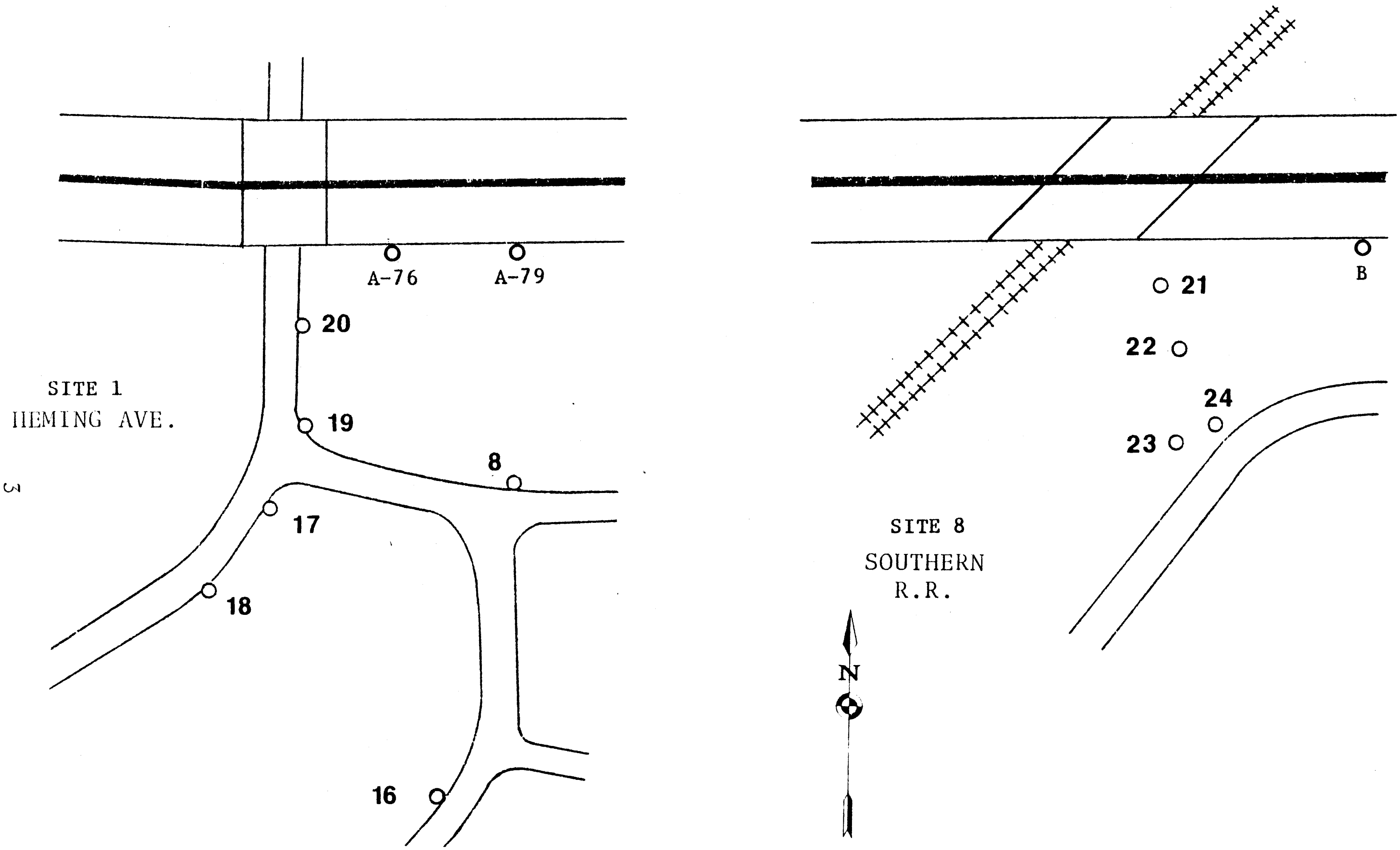

Figure 1. Plan views of bridge barrier measurement locations.

the surface west of the measurement traverse is asphaltic concrete for 11.6 m. (38 ft.) while except for the intersection with Long Pine Drive, the surface east of that line is covered with grass for approximately 7.6 m. (25 ft.) and then with deciduous trees. See Table 1 for the geometric data for the measurement locations.

At site number 8, I-495 bridges the main line of the Southern Railroad, which is in a 3.0 to 4.6 m. (10 to 15 ft.) depression. The measurement traverse runs south from the interstate toward the end of a row of apartment buildings across weed- and grass-covered terrain.

NOISE MEASUREMENTS

In the Heming Avenue area, the waterproofed microphone was set alongside I-495, or on the barrier after it had been completed, in the identical locations used in the neighborhood study described in reference 3, while the outdoor microphone was placed successively at four locations alongside Heming Avenue. At site number 8, the waterproofed microphone was set on the barrier, while the outdoor microphone was placed in turn at four locations in a field below the bridge and alongside the railroad. More details of these installations are given in Figures 2 and 3.

In 1976, before the installation of any barriers, noise measurements were made at only the Heming Avenue site. In 1978, after construction of the barriers along the roadside but before construction of the barriers on the bridges, measurements were taken at both sites. After installation of the ARMCO barriers to provide over 1,524 m. (5,000 ft.) of unbroken barrier in 1979, measurements were taken at both sites, with the exception that no measurements were made at location number 24 near the railroad.

Complete summaries of the computer analyses made in accordance with the methods described in reference 2 are given in Part B of reference 3. Note that because of a malfunction of the digital tape recorder the eight measurements made in 1978 had to be analyzed from the NAGRA analog tape recordings. Measured hourly traffic rates are shown in Tables 2 and 3.

Table 1

Measurements from Sections Perpendicular to Road from Median Centerline of I-495
Dimensions in Feet (x 0.3048 to convert to meters)

	Location		Barrier		Intercept on Median		Angles Subtended by Gap	
No.	Distance	Elevation	Distance	Elevation	Station	Elevation	West	East
17	360	250.8	70	287.4	566 + 32	272.2	$-23^\circ 00'$	$+20^\circ 45'$
18	443	250.8	70	287.4	566 + 98	271.7	$-08^\circ 30'$	$+23^\circ 00'$
19	265	250.3	70	287.4	565 + 95	272.6	$-42^\circ 00'$	$+19^\circ 45'$
20	160	252.0	70	287.4	566 + 00	272.6	$-71^\circ 00'$	$+41^\circ 45'$
21	110	272.5	70	295.7	529 + 40	281.5	$-92^\circ 00'$	$+81^\circ 00'$
22	178	270.4	70	295.7	528 + 95	280.6	$-80^\circ 30'$	$+40^\circ 00'$
23	280	274.0	70	295.7	529 + 25	281.0	$-67^\circ 15'$	$+21^\circ 30'$
24	255	271.6	81	295.7	528 + 80	280.3	$-71^\circ 45'$	$+10^\circ 00'$
A-76	87	291.2	---	---	565 + 25	272.7	---	---
A-79	90	293.0	90	288.0	563 + 90	273.4	---	---
B	90	300.5	90	295.5	527 + 03	278.8	---	---

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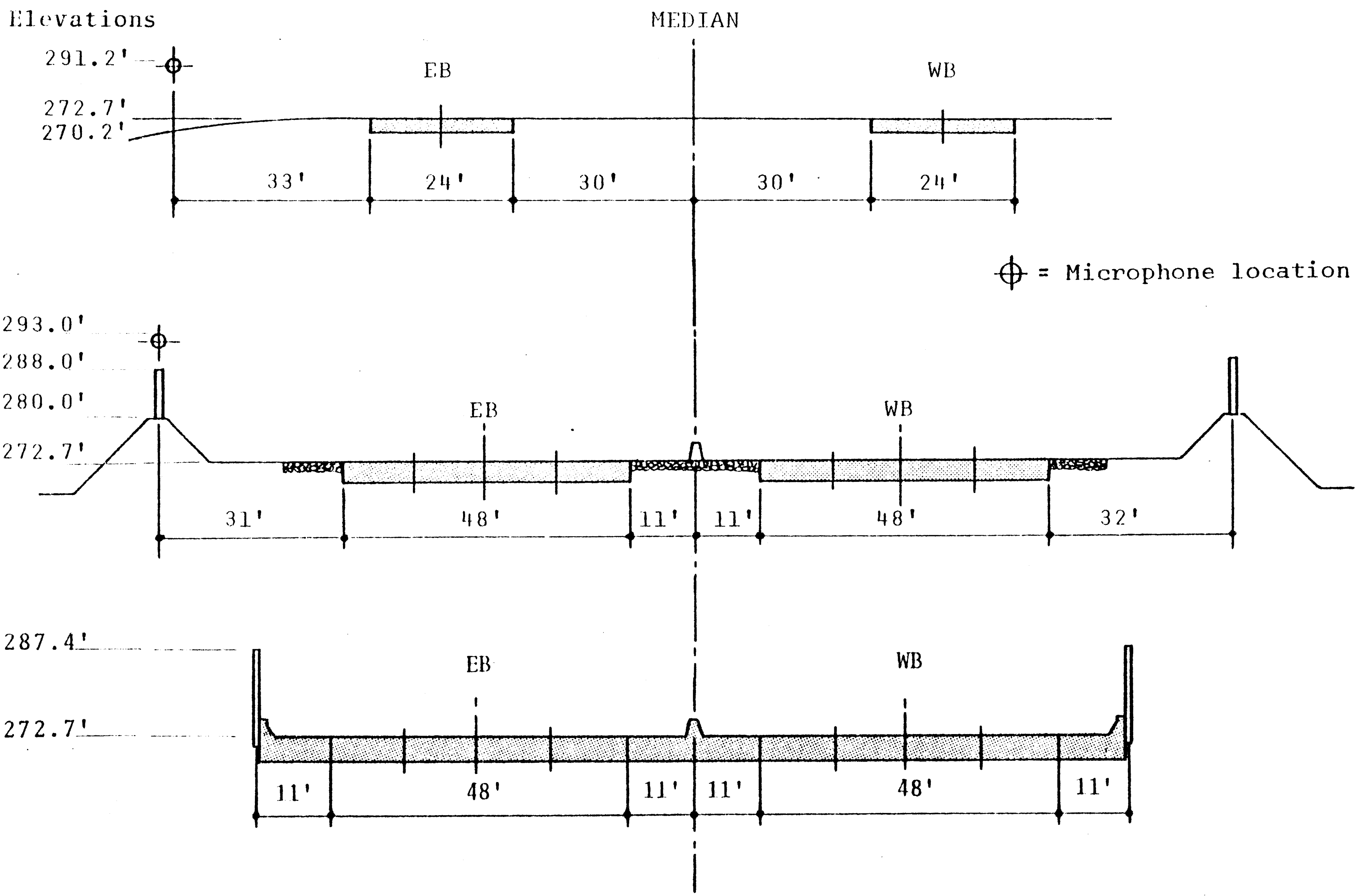

Figure 2. Site 1. Original roadway of two 12-ft. lanes in each direction prior to 1976 (top) modified to four 12-ft. lanes in each direction in 1979 (middle). Bridge section in 1979 at bottom.

1 ft. = 0.3048 meter.

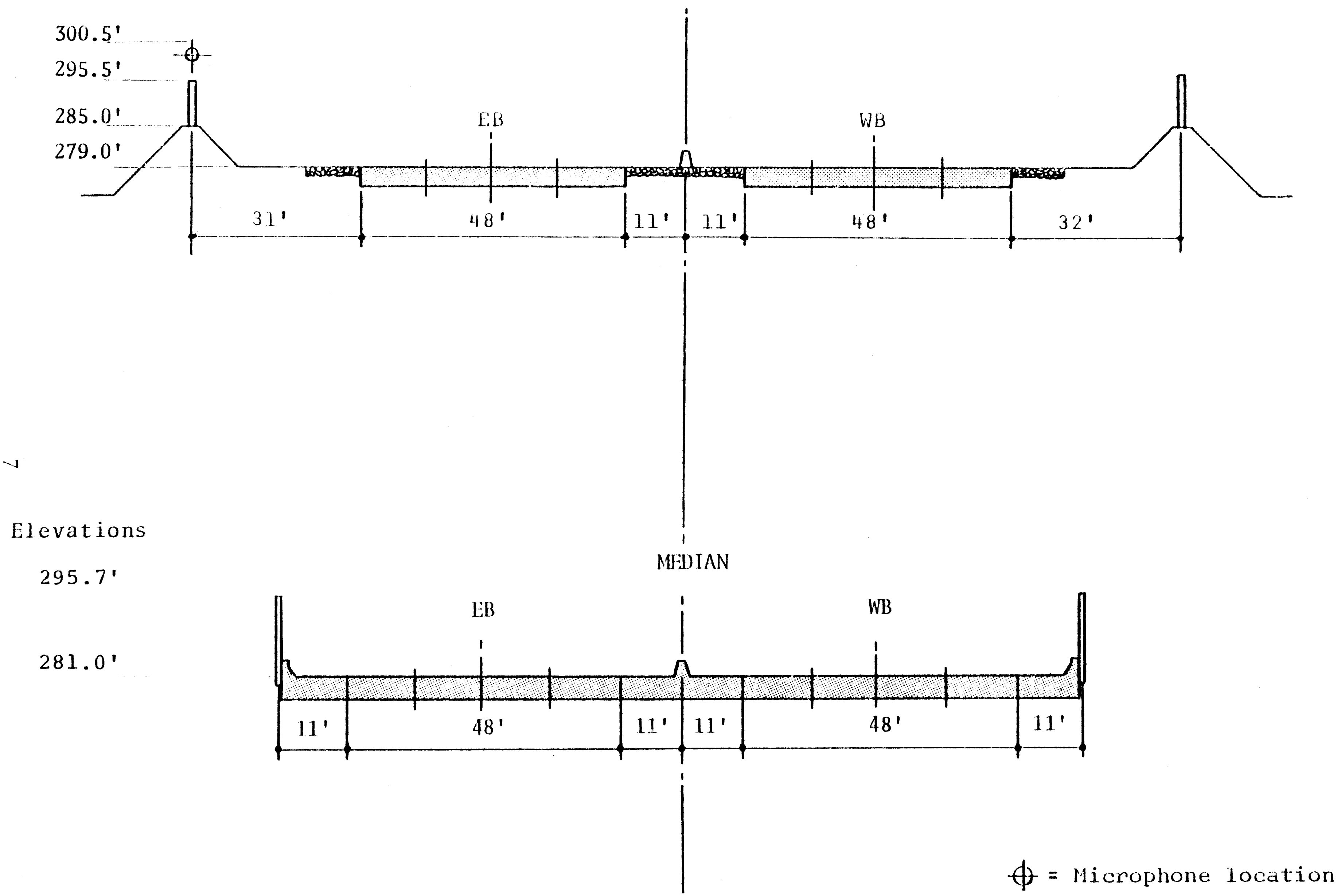

Figure 3. Site 8 in 1979. Roadway section – top, bridge section – bottom.

1 ft. = 0.3048 meter.

Table 2

Short Traffic Counts on I-495 For Bridge Barrier Study

Date/Time	Lane	No. Vehicles Passing: Autos	Med. Trucks	Heavy Trucks	Speed
Bridge at Heming					
8/23/78	EB	711	61	28	57
1422-1437	WB	757	39	39	53
8/23/78	EB	742	59	40	58
1446-1501	WB	780	37	32	54
8/23/78	EB	776	51	38	57
1514-1529	WB	904	49	44	52
8/23/78	EB	1156	67	43	57
1540-1555	WB	1210	32	30	47
Bridge at R.R.					
8/24/78	EB	717	44	49	58
1105-1120	WB	634	55	38	52
8/24/78	EB	694	53	51	56
1129-1144	WB	631	35	51	52
8/24/78	EB	656	49	54	58
1156-1211	WB	614	33	40	53
8/24/78	EB	723	55	53	56
1215-1230	WB	618	41	43	51
Bridge at R.R.					
9/17/79	EB	788	20	54	---
1500-1515	WB	822	55	60	---
9/17/79	EB	1290	32	40	---
1545-1600	WB	1091	48	47	---
9/17/79	EB	1254	10	19	---
1615-1630	WB	1254	45	34	---
Bridge at Heming					
9/18/79	EB	628	16	41	---
1045-1100	WB	499	39	59	---
9/18/79	EB	654	39	38	---
1115-1130	WB	542	44	51	---
9/18/79	EB	609	50	43	---
1204-1219	WB	565	39	57	---
9/18/79	EB	696	56	48	---
1235-1250	WB	619	50	44	---

Table 3

Short Traffic Counts on Heming Avenue and Long Pine Drive - Bridge Barriers

		No. Vehicles			Passing
Date/Time	Road	Autos	Medium Trucks	Heavy Trucks	Speed
8/23/78	Heming	59	3	---	---
1422-1437	Long Pine	31	---	---	---
8/23/78	Heming	63	2	---	---
1446-1501	Long Pine	---	---	---	---
8/23/78	Heming	61	1	---	---
1514-1529	Long Pine	26	1	---	---
8/23/78	Heming	104	3	---	---
1540-1555	Long Pine	---	---	---	---

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DISCUSSION

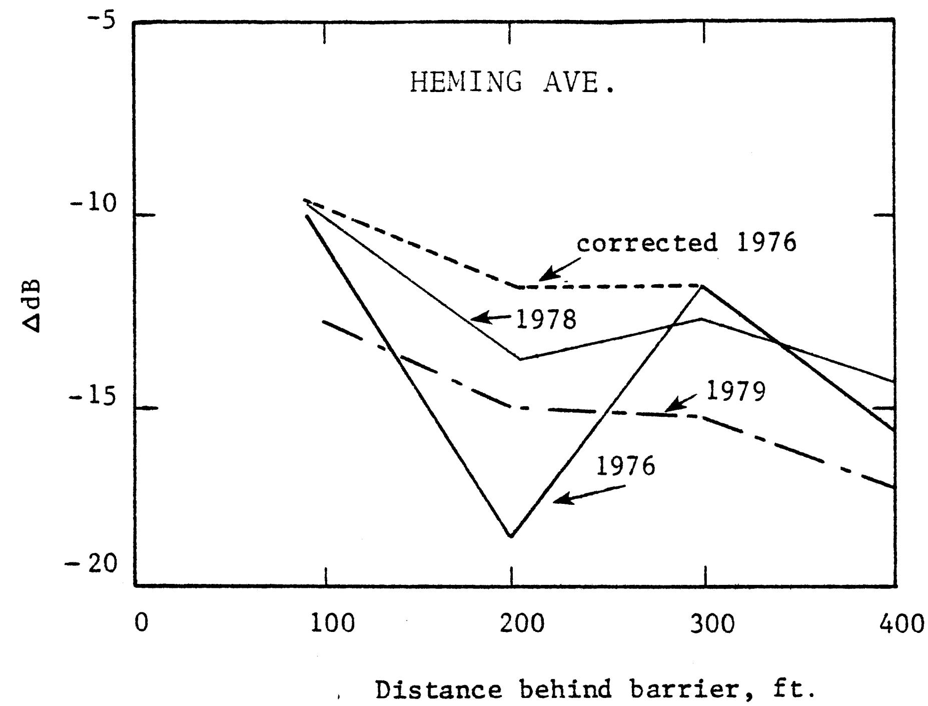
A summary of the LEQ values for the eight measurement locations is given in Table 4, as well as in Part B of reference 3. Values are given for the barrier location and for the measurement location, together with values of the drop-offs in these readings. The drop-offs are due to the effects of both distance and intervening shoulders, terrain, or barriers. The drop-offs are also plotted in Figure 4. If other things remain unchanged, the drop-offs should change only, at least within typical measurement accuracy, if a barrier has been added.

Table 4

Summary of LEQ Values and Drop-Offs

	1976			1978			1979		
Locn.	Barr.	Locn.	Drop	Barr.	Locn.	Drop	Barr.	Locn.	Drop
17	74.1	62.4	-11.7	78.6	66.0	-12.6	78.7	63.2	-15.5
18	76.2	61.0	-15.2	80.3	66.3	-14.0	78.7	61.4	-17.3
19	82.5	63.7	-18.8	79.7	66.0	-13.7	78.2	62.9	-15.3
20	74.5	64.6	- 9.9	79.9	70.2	- 9.7	78.9	65.9	-13.0
21	----	----	----	78.3	70.5	- 7.8	78.5	66.8	-11.7
22	----	----	----	78.4	66.4	-12.0	79.5	62.2	-17.3
23	----	----	----	78.4	65.3	-13.1	79.2	59.6	-19.6
24	----	----	----	78.3	64.0	-14.3	----	----	----

It will be noted that at the Heming Avenue site, the drop-offs between LEQ values changed little, or even decreased, when the road barriers were added. This fact, although surprising at first, seems to have been due to the opening up of the outer lanes of I-495 after the barriers had been installed on the roads, thereby bringing the traffic closer to the edge of the bridge. Of special interest here is the fact that the drop-off



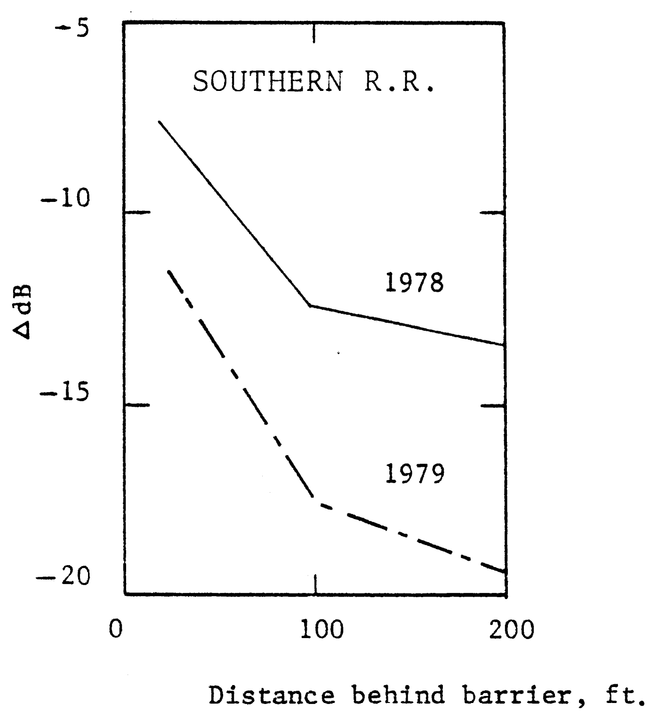


Figure 4. Drop-offs between the location and barrier measurements in LEQ for Heming Avenue (top) and Southern Railroad bridge (bottom).

1 ft. = 0.3048 meter.

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for one of the 1976 measurement locations at Heming Avenue, which was 62.5 m. (205 ft.) from I-495, does not fit the rest of the data. The drop-off for the no-barrier condition was 5 dB greater than the drop-off after the roadside barrier was constructed. In looking for an explanation for this anomaly, a note was found on the field sheet for the preceding measurement period which stated that channel 1 was overloaded, showed frequent "bit patterns", and was running 7 dB high. (It should be noted that the phenomenon of bit patterns was later tied to imperfect grounding and was corrected after 1976.) If this problem with channel 1, which occurred intermittently, were to have occurred during the measurement starting at 1510 on June 14, 1976, the measured LEQ could have been as much as 7 dB high, so that the revised drop-off shown by the dashed line in Figure 4 would be more realistic. It should be mentioned here that the "before" measurements were made after the bridges had been widened. However, between the installation of the road barriers and the addition of the ARMCO barriers, there were no other alterations, so that the changes in the LEQ drop-offs shown can be attributed to the ARMCO barriers. It will be noted that these changes were between 1.6 and 6.5 decibels, which indicates that they had a positive effect and made a contribution to noise reduction.

While the data in Table 4 indicate that the bridge barriers had a positive effect, one aspect of the data is questionable and requires an explanation. That is, the change in the drop-off for the Heming Avenue site (1.6 to 3.3) is less than for the Southern Railroad site (3.9 to 6.5).

Certain physical conditions related to noise may be thought of as constants because of their slow rate of change. Vegetation, ground cover, and structures are essentially constants for any given measurement location. The most obvious variable is traffic. If a group of measurement locations is affected by two sources of traffic noise, and a barrier is inserted between these locations and the major source of noise, then the second source of noise will become a more important factor relative to the noise level at these locations. Thus the traffic that moves over Heming Avenue and Long Pine Drive, though not particularly heavy, passed close to the microphone at the measurement location and could have caused the change in drop-off at site number 1 to be less than that at site number 8.

In addition, a very annoying traffic-related but non-traffic noise was observed in the vicinity of the bridge over Heming Avenue. The noise was a combination of a clatter and a boom and occurred each time a vehicle ran over one or more of the expansion joints in the bridge deck. The noise seemed to reverberate under the bridge. The noise was not identical each time it occurred so it is possible that not all the joints nor all sections of the joints reacted in the same way. Also, the noise seemed to vary with the size and speed of the vehicles. Fast-moving, heavy trucks caused the loudest noise.

No attempt was made to link these measured results with analytical predictions, because it was felt that the current analytical programs were not capable of producing reasonable predictions in cases such as this.

CONCLUSIONS

1. Whenever a noise barrier is interrupted, there is inevitably some degradation of its performance. Such is the case when the roadway crosses a bridge whose structure is incompatible with the method used to secure the roadside barrier. The effect is much more pronounced in the immediate vicinity of the bridge than elsewhere.

2. Use of a specially designed barrier on such a bridge can effectively reduce the traffic noise that penetrates the immediate vicinity.

3. The ARMCO double-wall, steel barriers installed at the two sites studied do an effective job of controlling noise.

4. The expansion joints on bridges can generate an annoying noise.

RECOMMENDATIONS

1. Specially designed barriers of the ARMCO type should be used on bridges which would otherwise cause interruptions in a noise barrier.

2. Such barriers should be approximately the same height as the barriers that are interrupted, but can be of different material and design, so far as overall effectiveness is concerned.

3. This study did not cover aesthetic considerations; however, it obviously would be desirable to match the overall appearance of the interrupted barrier as far as is practicable.

4. The expansion joints on bridges should be checked, and steps should be taken to repair or replace ones causing noise.

REFERENCES

1. Noble, D. F., and J. K. Haviland, "Working Plan – Evaluation of ARMCO Sound Barriers on Two Bridges on I-495", Virginia Highway and Transportation Research Council, Charlottesville, Virginia, Report No. VHTRC 76-WP33, March 1976.

2. Haviland, J. K., and D. F. Noble, "Effectiveness of Predictive Computer Programs in the Design of Noise Barriers – A Before and After Approach – Part I. The Data Acquisition System", Virginia Highway and Transportation Research Council, Charlottesville, Virginia, Report No. VHTRC 78-R32, February 1978.

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