PRELIMINARY REPORT

EVALUATION OF STANDING NOISE BARRIERS

by

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SUMMARY

A series of tests have been carried out at six sites for the evaluation of noise barriers to determine their relative effectiveness. Two barriers were metal, two were wooden, and one was concrete. One site, used for reference, had no barrier. The effectiveness of the measurements was somewhat reduced by low-flying aircraft and by a high noise floor on one microphone. However, because a sophisticated data collection system was used, useful results were obtained. These results indicate that all of the barriers perform up to the relevant design curves.

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INSTRUMENTATION

The test program briefly reported here constitutes the first phase of a two-phase study of noise barriers either constructed or to be constructed by the Department.(1) The data acquisition system used was that described in reference 2, except that it was expanded to four channels (out of a total capability of eight). Two additional sound level meters, together with 430 feet of cable and an additional NAGRA tape recorder, were borrowed so that recordings could be made on four channels simultaneously. Three 1/2-inch microphones were mounted at adjustable locations on a 30-foot pole, while the fourth, 5 feet above the ground, was part of the all-weather microphone system. The outputs from the four microphones were A-weighted in the recording van using four B&K 2204 or 2209 sound level meters. The DC outputs were fed to an A-D converter for recording on digital tape, while the AC outputs were fed to the four input channels of two NAGRA recorders.

RECORDING PROCEDURES

At each of the six sites (numbered from 2 to 7), up to four locations were selected for making recordings, taking into account the following criteria.

(a) Distances behind the barrier should vary from 10-20 feet to about 200 feet.

(b) Obstacles such as trees and houses should be avoided as much as possible.

(c) Nontraffic noise should be minimized.

(d) The top two microphones should be higher than the barrier.

Before first erecting the pole, calibration tones were applied to all of the microphones, and the calibration screw of the corresponding meter was adjusted so that the meter would read 12.2 dB (off the scale) at the estimated L_{10} level. The figure of 12.2 dB was selected because it corresponds to a 5-volt input to the A-D converter, which is half of the maximum 10-volt input. Thus, there was a 6 dB margin on voltage, and a 4.7 dB margin on the maximum sound level meter output. Calibration signals for data analysis were recorded from the reference tones of the sound level meters using a method derived from that described in reference 2.

Fifteen-minute recordings were made at each location, both on the digital tape recorder and on the NAGRAs. The digital recorder malfunctioned at site #7; however, the NAGRA tapes were played back to obtain the digital tapes in the laboratory after the digital recorder had been repaired. Table 1 summarizes the recordings made.

DATA ANALYSES

All of the available digital tapes were analyzed to obtain L_E (percentage exceedance) levels, L_{EQ}, LNP, NPL, TN1, and the variances L_{SIG} and L_{EPS}. Strip chart recordings were made of the NAGRA Tapes.

It was immediately obvious that the threshold levels on the all-weather microphone were excessive, as had been feared during the measurements. Subsequent investigations in the laboratory have shown that the trouble came from a noisy heater power supply. This trouble will be rectified before any further measurements are made. For future reference, the lowest A-weighted noise threshold was found to be 37 dB with the weighting set to linear (and the 2204 set to A), the gain set to 50 dB, and the heater, of course, off.

Table 1

Summary of Recordings

Site #	Description	Locn. #	Distance From Barrier (feet)	No. of NAGRA Channels	No. of Digital Channels	Tape #	Figure #
2	Denbigh Blvd.	1	25	4	4	41	1
	(Newport News)	2	50	4	4	41	
	Metal Barrier	3	100	4	4	41	
		4	150	4	4	41	
3	Great Neck Rd.	1	12	4	4	40	2
	(Virginia Beach)	2	25	4	4	40	
	Wooden barrier	3	75	4	4	40	
		4	100	4	4	40	
4	I-64	1	25	4	4	39	3
	(Hampton)	2	50	4	4	39	
	Metal barrier	3	75	4	4	39	
		4	100	4	4	39	
5	Churchland Br.	1	9	4	4	38	4
	(Portsmouth)	2	38.5	4	4	38	
	Wooden barrier						
6	I-495	1	10	4	4	37	5
	(Springfield)	2	25	4	4	37	
	Concrete barrier	3	75	4	4	37	
	on earth berm	4	150	4	4	37	
7	29 North	1	50	4	4	26	6
	(Near Ch'ville)	2	100	4	4	26	
	No barrier	3	150	4	4	26	
		4	200	4	4	26	
-	I-680	E	25	Results reported in			8
	(Milpitas, CA)	B	50	NCHRP 144 & 173			
	Masonary barrier	C	100	" " "			
	on earth berm	D	200	" " "			

RESULTS

Results of the measurements at sites 2-7 are shown in Figures 1-6 (all figures are attached). The solid lines display L_1, L_{10}, L_{50}, and L_{90} averaged over 15 minutes, while the broken curves show relative attenuation according to the NCHRP 174 (reference 3) procedure, with the noise source located on the road surface at the center of the first lane (see symbol). For the nearest location to the barrier, the relative attenuation is also shown for a noise source 8 feet above the road, the area between the two curves being shaded.

A comparison of the NCHRP 174 barrier design curve with the NCHRP 117 (reference 4) curve, which is presently used by the Department, is shown in Figure 7. There are some differences below the line of sight, in fact the NCHRP 174 curve goes to 20 dB attenuation vs. 15 dB for the curve used now. Some attenuation is also allowed above the line of sight in the newer curve, whereas none is allowed with the present curve.

Similar test data have been extracted from NCHRP 144 (reference 5) and 173, and are shown in Figure 8, which includes the ranges of L_{50} values (solid bars), the calculated attenuation (double broken curve) based on NCHRP 173, and the attenuation calculated by NCHRP 174 method (broken curve) described above.

The difference between the two sets of attenuation curves is seen to be relatively minor. It stems in part from the more accurate method of accounting for traffic location used in NCHRP 173, and in part from the fact that NCHRP 173 used the NCHRP 117 design curve. (The NCHRP 173 results are based on the NCHRP 117 design curves, but are used to justify the NCHRP 174 design curves.)

One problem with the NCHRP 173 measurements is that data for a given location at different heights were obtained at different times because the researchers were trying to get distance attenuation effects rather than height effects. However, NCHRP 173 includes a statistical analysis according to which there is no height effect up to 15 feet at any distance up to 1,600 feet from the road.

INTERPRETATION OF RESULTS

In interpreting the results shown in Figures 1-5, one should remember that if all of the noise sources were as shown, the L_1, L_{10}, L_{50}, L_{90}, and theoretical attenuation curves should all have the same shape, although they would be relatively displaced. Evidently, this was not always the case, possibly for one of the following three reasons.

1) Uncertainty about noise source location. L_1 and L_{10} producing sources, like truck exhausts, tend to be high and thus to minimize the barrier effects. This tendency, in turn, will tend to make L_1 and L_{10} "stand up" here and become nearer to the vertical than will the L_{50} and L_{90} curves.

2) Aircraft are powerful L_1 and L_{10} producers, while their noise is unaffected by barriers. They were particularly bad at the 100-foot location on Great Neck Road; note that the L_1, L_{10} curves in Figure 2, which stand almost straight up.

3) The high noise threshold on the lower all-weather microphone tends to make the L_{50} and L_{90} curves converge. This might look like a "leak" through the barrier, but it is entirely an instrumentation problem.

The data presented in Figure 6 were obtained without any barrier for comparison with the preceding data. Some slight attenuation is noticeable at the lower microphones in the figure; however, it does not seem to increase with distance, thus confirming the finding previously quoted from NCHRP — namely, that the distance attenuation effect is independent of height above the ground.

The NCHRP recommendation is that the propagation loss factor (dB reduction with distance) be taken as between 3 dB per doubling (of distance) over smooth ground to 4.5 dB per doubling over lush vegetation, independent of the height above the ground up to 15 feet. The theoretical factor, in the absence of the ground plane, would be 3 dB per doubling, and the presumption has always been that this factor would be approached at some height above the ground.

The data presented in Figure 6 suggest that there is a small immediate loss of 1-2 dB in the first 500 feet from the road, but that the propagation loss factor is then independent of height up to 30 feet. On closer inspection, Figure 6 seems to show a small dependency on the angle made between the microphone, the source, and the ground. However, much more careful measurement would be required to confirm this.

In interpreting the results shown in Figures 1-6, it should be remembered that for locations near the road the upper microphones are further from the source than those vertically beneath them. This distance effect will cause some additional attenuation not accounted for in the current analysis procedures nor in the theoretical attenuation curves shown (broken curves).

CONCLUSIONS

1. The barriers studied all perform to the theoretical curves given in NCHRP 174, and thus better than the presently used curves, at least within the accuracy of the reported measurements.
2. The exceedance level (L_{10}, L_{50}, etc.) has proved to be extremely useful in this work because short-term noise sources, such as aircraft, tend to affect only L_1, and perhaps L_{10}, leaving lower levels, such as L_{50}, unaffected.
3. Notwithstanding item 2, for future measurements the system should include a method of stopping the recording during aircraft flyovers or other nontraffic disturbances.

REFERENCES

1. Haviland, J. K., and D. F. Noble, "Tentative Working Plan — Evaluation of Standing Noise Barriers", unpublished, May 1978.

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", VHTRC 78-R32, to be released.

3. Bolt, Beranek, and Newman, "Highway Noise. A Design Guide for Prediction and Control", NCHRP 174, Los Angeles, California, 1976.

4. ______________________, "Highway Noise. A Design Guide for Highway Engineers", NCHRP 117, Los Angeles, California, 1971.

5. ______________________, "Highway Noise. A Field Evaluation of Traffic Noise Reduction Methods", NCHRP 144, Los Angeles, California, 1973.

6. ______________________, "Highway Noise. Generation and Control", NCHRP 173, Los Angeles, California, 1976.

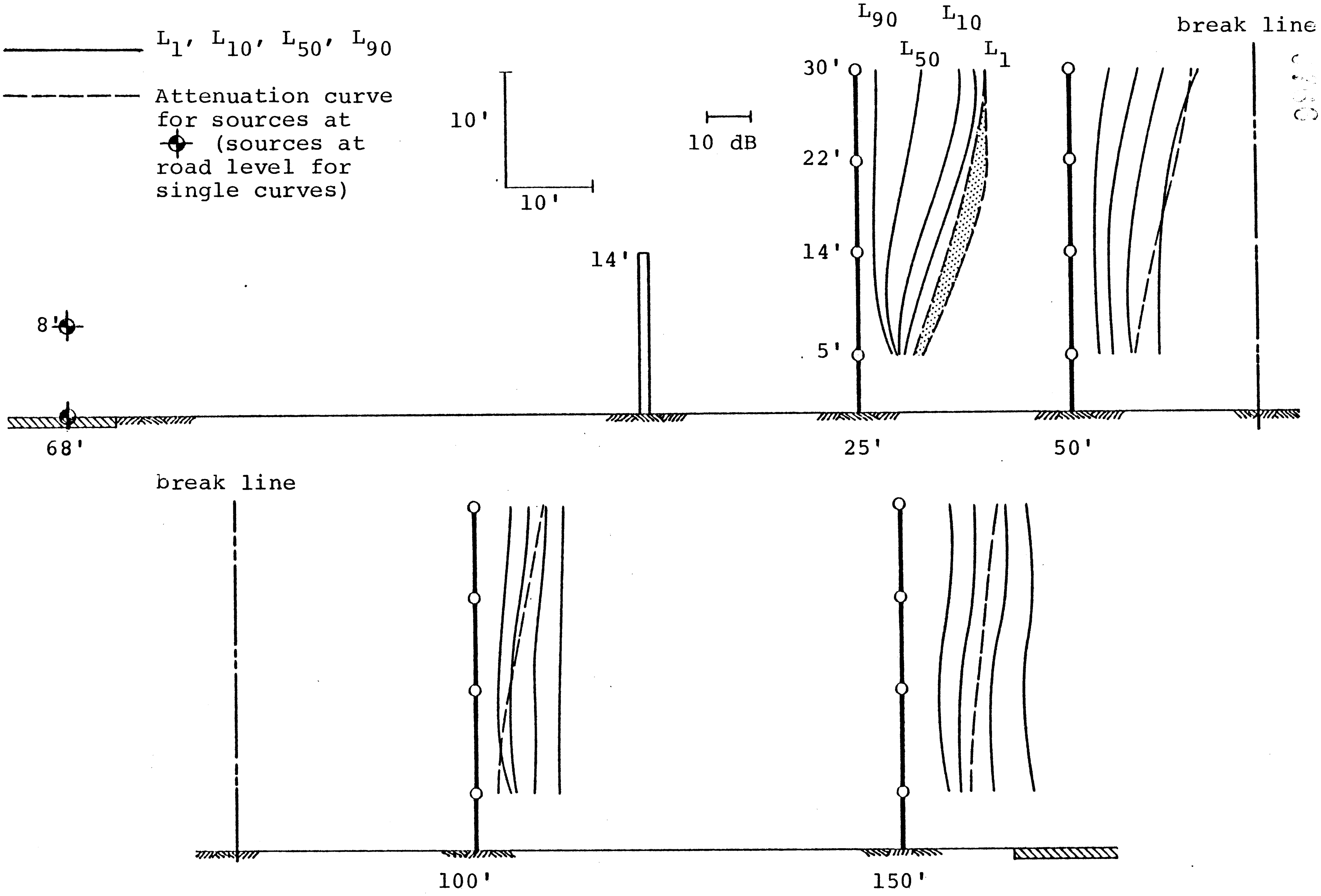

Figure 1. Barrier attenuation effects at Denbigh Blvd., Newport News.

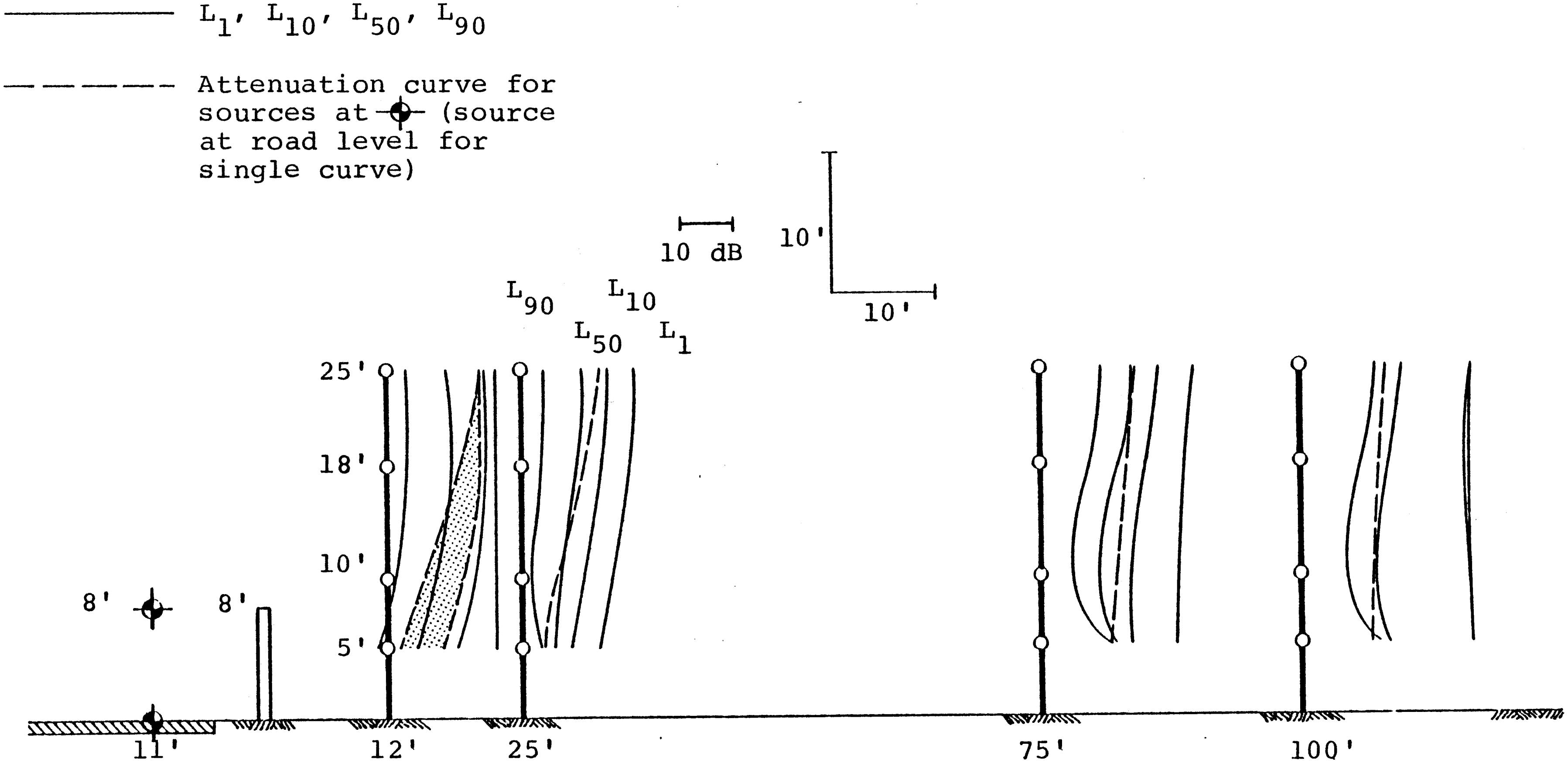

Figure 2. Barrier attenuation effects on Great Neck Rd., Virginia Beach.

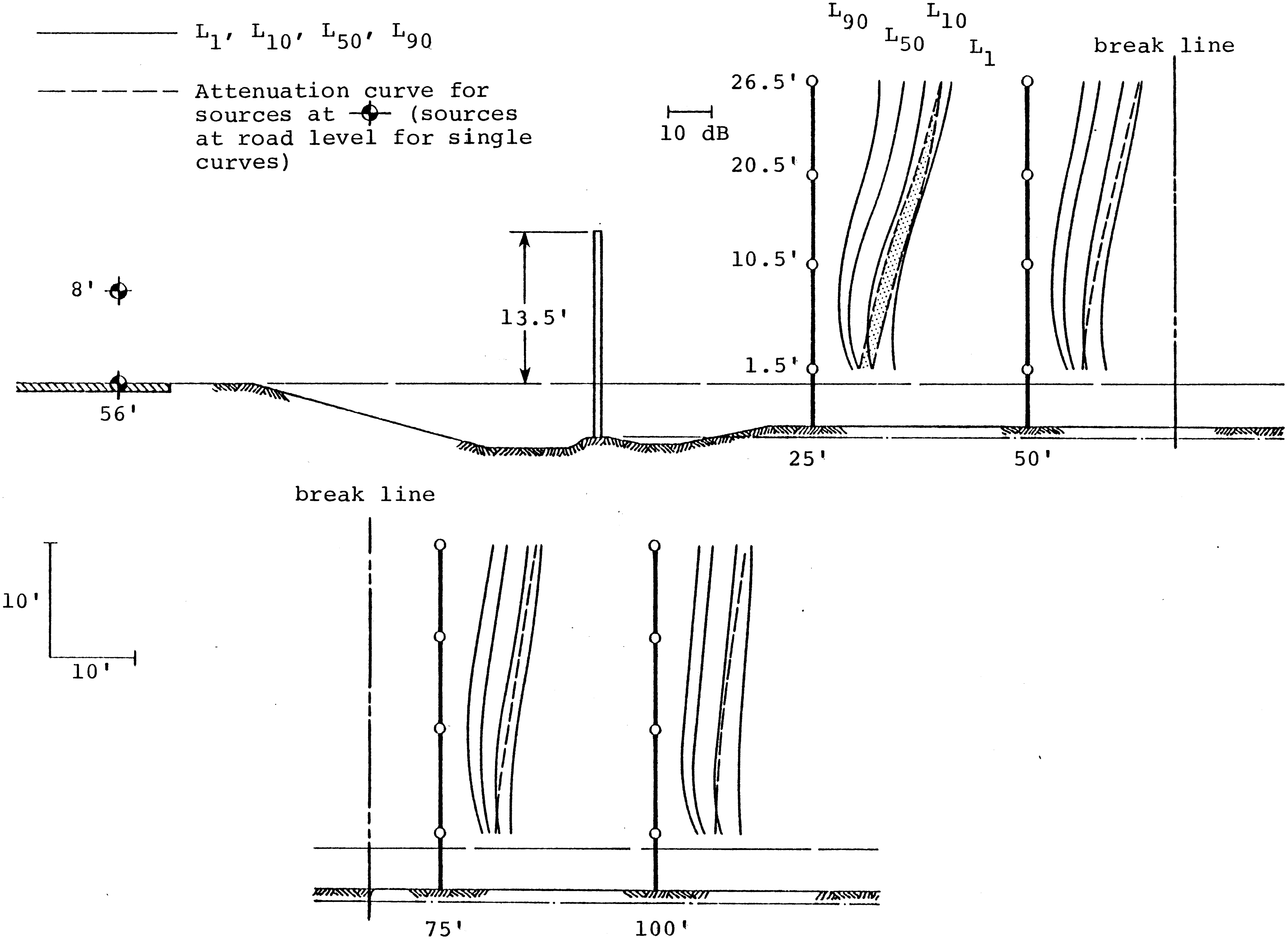

Figure 3. Barrier attenuation effects on I-64, Hampton.

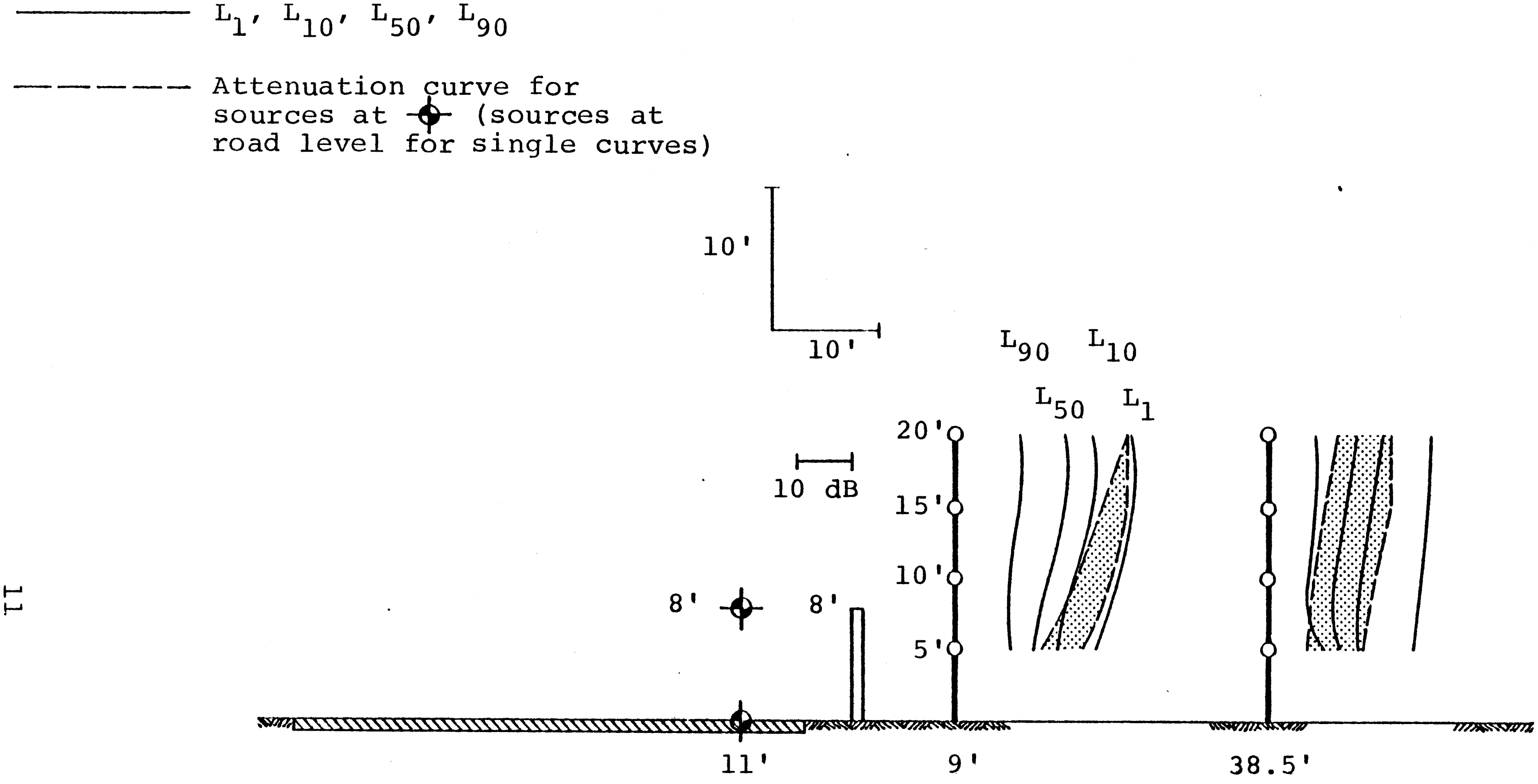

Figure 4. Barrier attenuation efffects at Churchland Bridge site, Portsmouth.

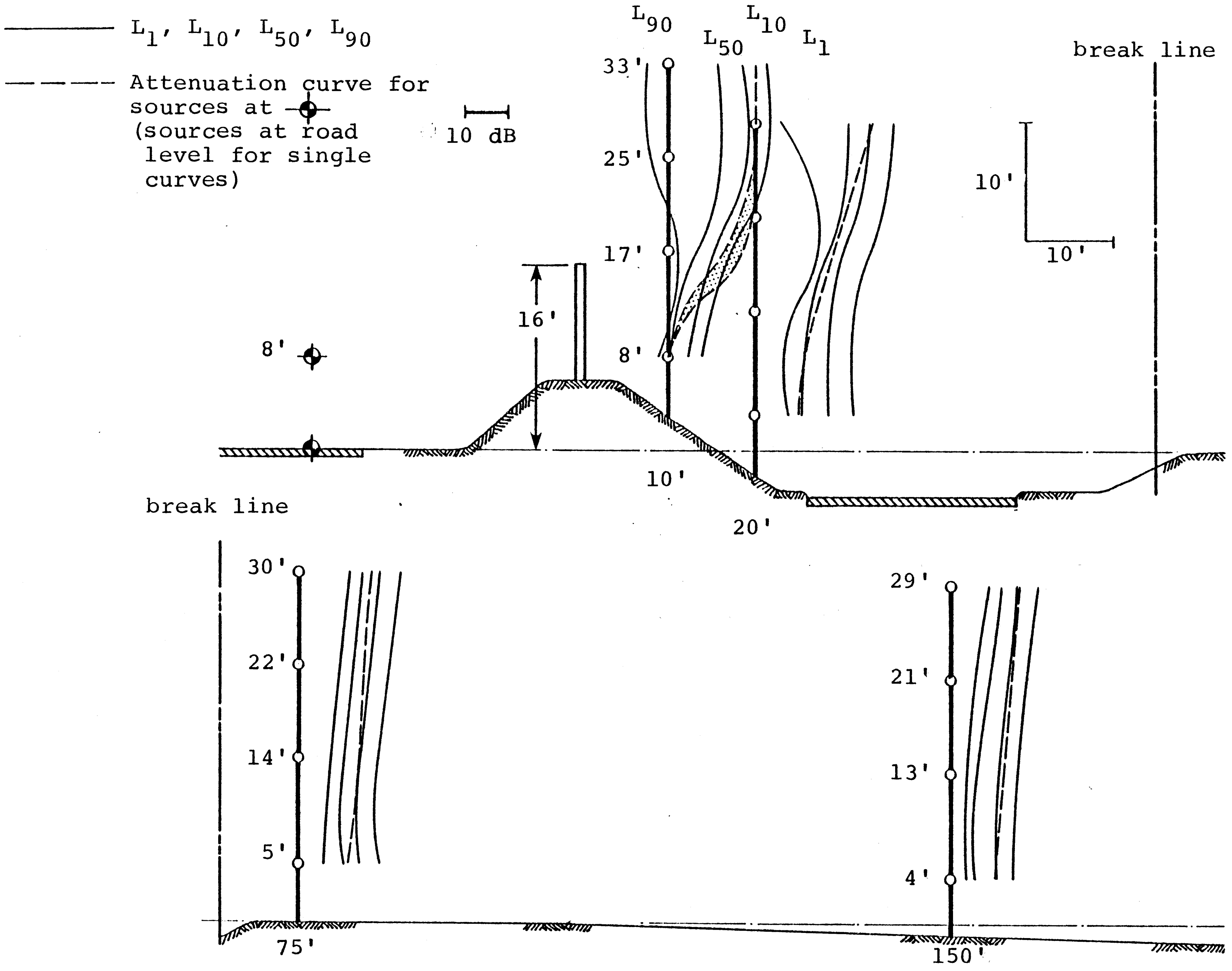

Figure 5. Barrier attenuation effects at I-495, Springfield.

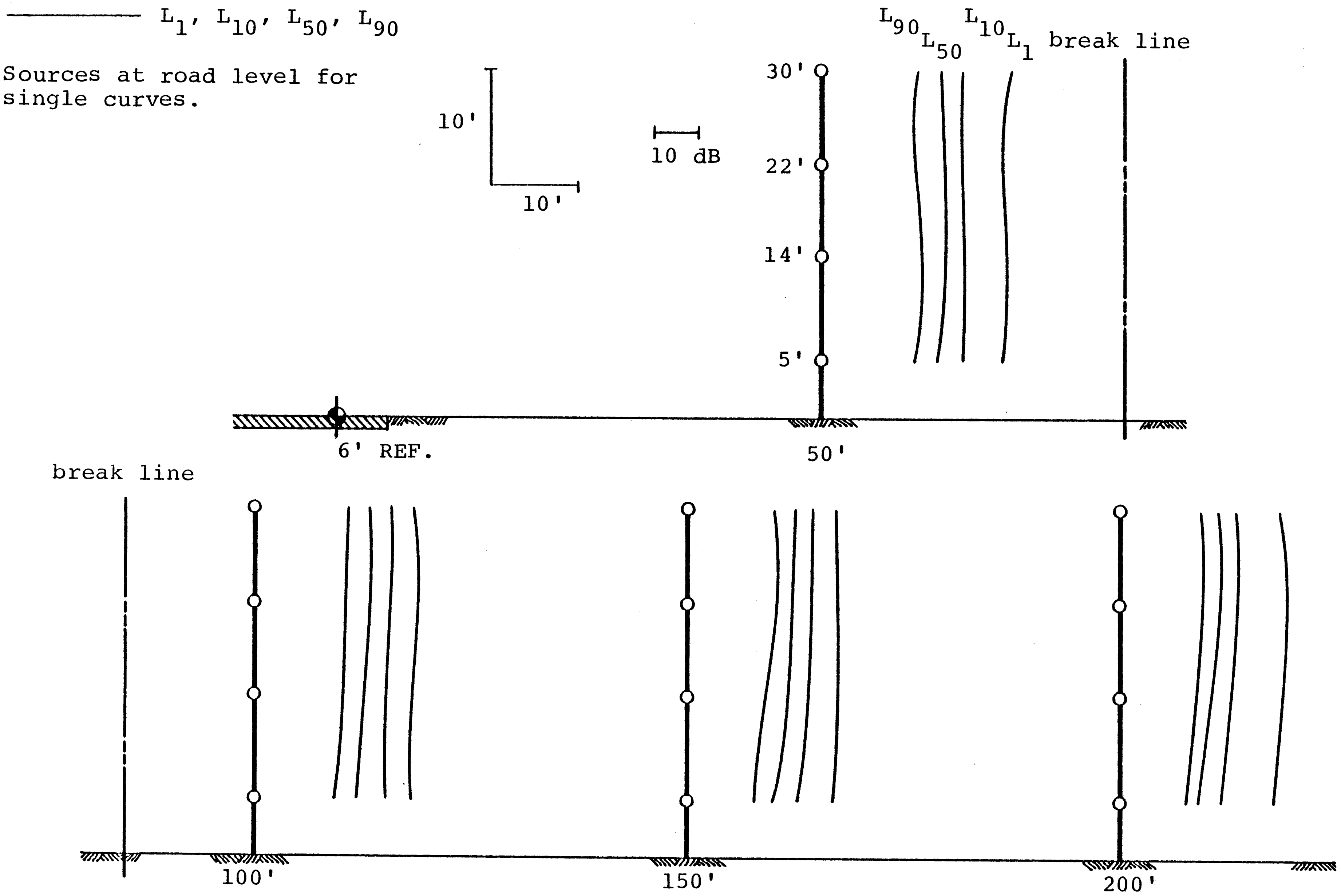

Figure 6. Attenuation over level ground. 29N, Charlottesville, (Sperry Marine Systems Plant)

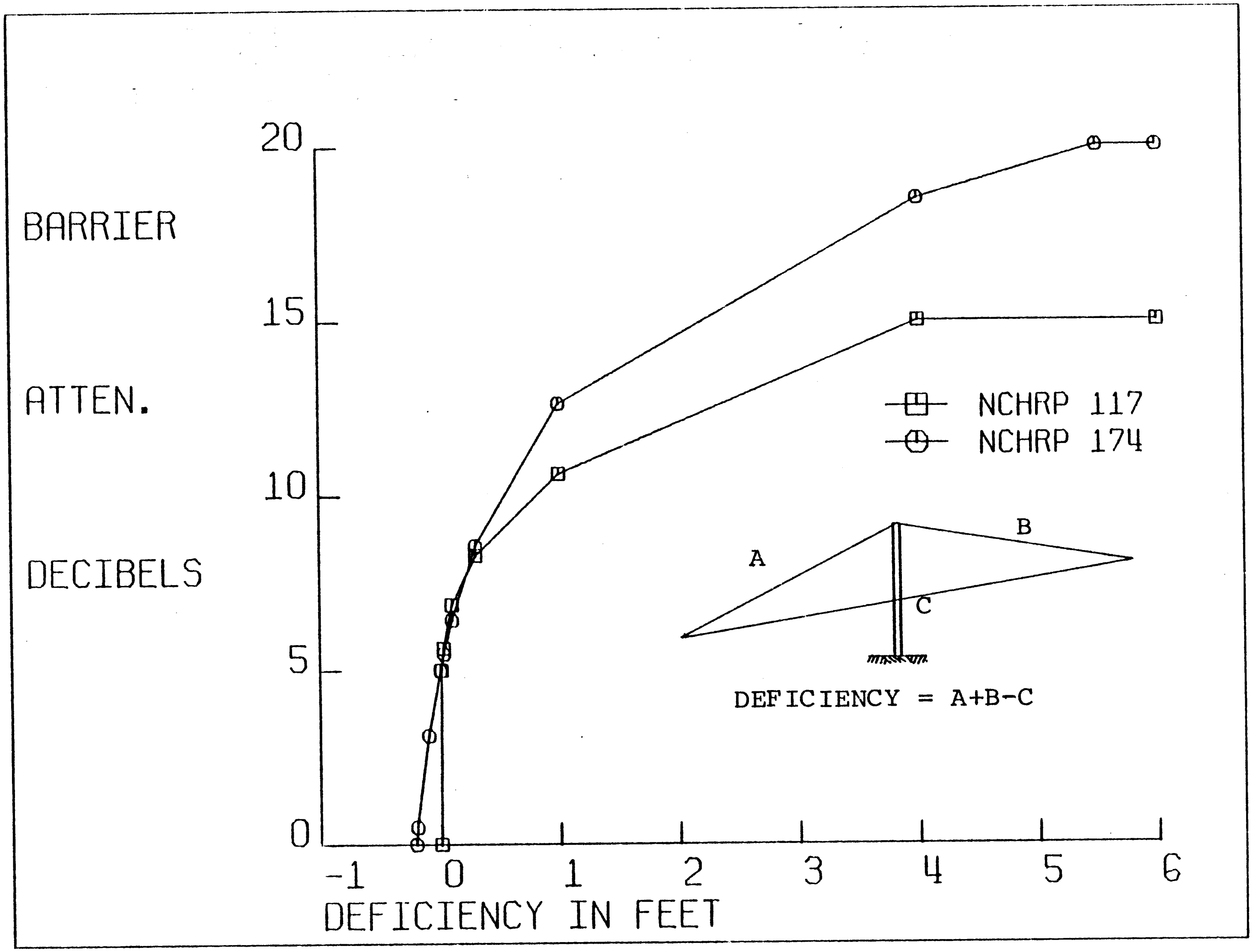

Figure 7. Comparison of barrier design curves from NCHRP 117 and 174.

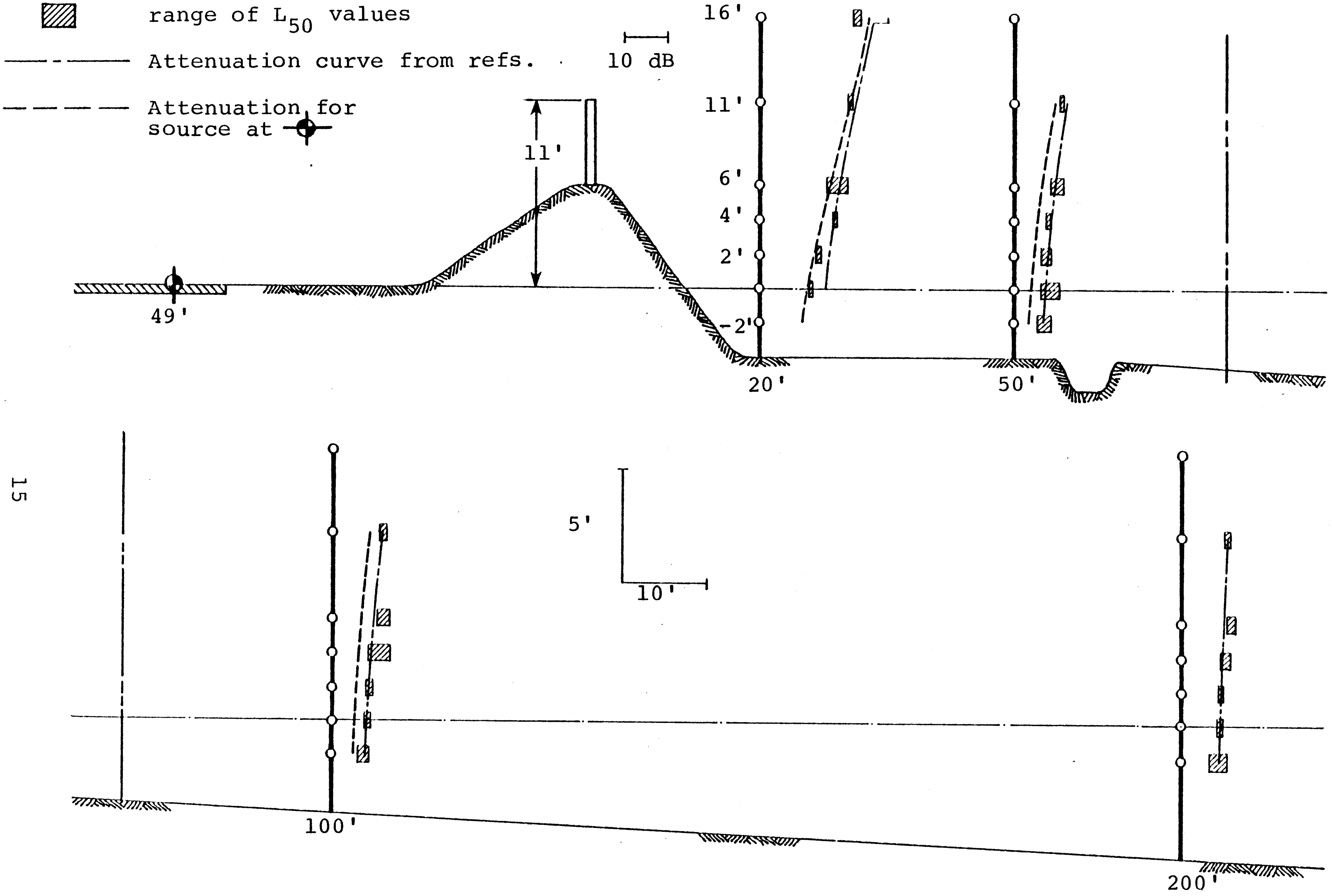

Figure 8. Barrier attenuation effects on I-680, Milpitas Ca., from NCHRP 144 and 173.