Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle
Effectiveness of Traffic Noise Barrier on I 471 in Campbell County, Kentucky (Interim Report)

5. Report Date
June 1984

6. Performing Organization Code

7. Author(s)
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8. Performing Organization Report No.
UKTRP-84-20

9. Performing Organization Name and Address
Kentucky Transportation Research Program
College of Engineering
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Lexington, Kentucky 40506-0043

10. Work Unit No. (TRAIS)

11. Contract or Grant No.
KYHPR-84-104

12. Sponsoring Agency Name and Address
Kentucky Transportation Cabinet
State Office Building
Frankfort, Kentucky 40622

13. Type of Report and Period Covered
Interim

14. Sponsoring Agency Code

15. Supplementary Notes
Study Title: Effectiveness of Traffic Noise Barriers

16. Abstract

The objective of this study is to evaluate the effectiveness of the traffic noise barrier on I 471 in Campbell County, Kentucky. Since the barrier construction coincided with construction of I 471, it was necessary to predict noise levels that would exist if no barrier were present by utilizing the FHWA STAMINA 2.0 computer model. This was compared to actual noise level measurements at the barrier site in order to determine the barrier insertion loss.

After calibration of the STAMINA 2.0 model, initial field measurements were taken at receiver locations throughout the barrier site. The average insertion loss in Leq was found to be 7.0 dBA, ranging from 3.5 dBA to 13.0 dBA. The average insertion loss in L10 was found to be 8.2 dBA, ranging from 5.0 dBA to 14.3 dBA.

A questionnaire to be used in a community perception survey was developed. The survey will be distributed and the results summarized in the final report.

17. Key Words
Traffic Noise Barrier
Insertion Loss
Receivers
Emission Levels
Model

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

Research Report
UKTRP-84-20

EFFECTIVENESS OF TRAFFIC NOISE BARRIER ON I 471 IN CAMPBELL COUNTY, KENTUCKY (INTERIM REPORT)

by

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in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
US Department of Transportation

June 1984

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INTRODUCTION

Traffic noise may reach such excessive levels at locations near major highways that noise abatement measures are necessary. One noise abatement measure used frequently across the United States involves a noise barrier along the highway. These barriers are vertical walls made of wood, metal, concrete, or earth berms. They are designed to reduce noise levels at sensitive receivers adjacent to the highway and to break the line of sight between vehicles on the highway and receivers.

Currently, only one noise barrier has been constructed in Kentucky. This barrier is located on Interstate 471 in Campbell County (Figure 1). This barrier is 15 feet high and is of metal construction. It is located adjacent to the shoulder of the interstate. The total length of the barrier is 2,550 feet. It was constructed in 1981, and its construction coincided with the construction of I 471. The cost of the metal noise barrier itself was $392,277 or $10.26 per square foot or $153.90 per linear foot. The total cost of the noise barrier construction project was $757,685.

The noise barrier was designed to shield traffic noise from a residential neighborhood adjacent to I 471. The objective of this study is to determine if noise reduction estimates are being achieved. Since this barrier is the first to be constructed in Kentucky, a determination of barrier effectiveness at this location will aid in future decisions regarding when and how additional noise barriers should be constructed. The construction of noise barriers is expensive, which means that the most efficient design must be used to minimize the amount of barrier area required while achieving the needed noise reduction. Any improvement in design would result in reduced construction costs as well as reductions in noise levels for the affected receivers.

Since the noise barrier was part of the construction of I 471, before-and-after data could not be obtained. This report describes the procedure that will be used to determine barrier field insertion loss. The modeling of the site is detailed along with the calibration procedure. Results of initial field measurements are presented. Detailed measurements and results will be contained in the final report. A survey developed to determine community perception of the noise barrier is also shown. This survey will be distributed and results documented in the final report.

DATA COLLECTION PROCEDURE

TECHNIQUE FOR DETERMINING INSERTION LOSS

Since construction of the noise barrier coincided with construction of I 471, before-and-after noise measurements could not be obtained. Also, there was not a similar site along the highway where there was no noise barrier so that measurements could be compared. It was decided to use the procedure described in Section 5.5 of FHWA report FHWA-DP-45-1R (1). That procedure utilizes the FHWA STAMINA 2.0 model to determine insertion loss by comparing actual "after" sound level measurements to predicted "before" levels. The STAMINA 2.0 model considers highway traffic noise in relation to a roadway source, which is approximated by a series of straight-line segments, and estimates the acoustic intensity at a receiver location resulting from the roadway source. Source characteristics are defined by speed-dependent noise emission levels and by traffic density by vehicle type. Site geography is described by a three-dimensional coordinate system. Source-receiver path characteristics are then considered, taking into account effects of noise barriers, topography, vegetation, and atmospheric absorption.

Two locations (behind the noise barrier) were selected and measurements were taken to calibrate the model. Once the calibration process was completed, "before" sound levels were predicted by the model. The insertion loss was determined by taking the difference between the calculated "before" and measured "after" noise levels.

MODEL CALIBRATION

The first step in the model calibration process was the physical modeling of the study site. This was done by quantifying physical characteristics of the microphone or receiver locations, vehicles, roadway, and barrier. Using maps, an aerial photograph, and a preliminary field inspection, locations for the study site and reference microphones were selected.

To locate the study site microphone, it was necessary to first establish a baseline perpendicular to the centerline of the near traffic lane, passing through the study site microphone location. The study site microphone had to be on the other side of the barrier (i.e. the barrier had to stand between the microphone and roadway) and had to be at least 10 feet from any vertical reflective surface. The geometry between the microphone and roadway was to be as simple as possible.

The reference microphone was to be located on the baseline in such a way that the noise barrier had no effect on it; it required an unobstructed view of the roadway through a subtended arc of at least 160 degrees. Due to the closeness of the noise barrier to the edge of the roadway, the only way to satisfy requirements for locating the reference microphone was to place it behind the noise barrier along the baseline and elevate it in such a manner that the barrier would have no effect (Figure 2). The reference microphone had to have a perpendicular clearance of 5 feet from a line originating at the near edge of the pavement and passing through the top front edge of the noise barrier. Using a tripod constructed of 1-inch diameter galvanized pipe, it was necessary to raise the microphone to a height of 28 feet in order to obtain the required perpendicular clearance (Figure 3). Locations of the microphones were expressed in terms of x, y, and z coordinates, with the z coordinate indicating the elevation of the microphone.

Four types of vehicles were considered: automobiles, light trucks, medium trucks, and heavy trucks. In terms of noise emission levels, all autos, pickup trucks and 12- or 15-passenger vans were grouped together. The light truck category consisted of delivery-type trucks larger than a van or pickup trucks having two axles and four tires. Single-unit trucks having two axles and six tires and buses were included in the medium truck category. Motorcycles also were placed in that category because they have similar noise emission levels. Single-unit trucks having three or more axles and all combination trucks were grouped into the heavy truck category. Corresponding source heights of 0.0, 0.0, 2.3 and 8.0 feet, respectively, were assigned to the categories and input into the STAMINA 2.0 model. Noise emission levels for the different vehicle types for Kentucky vehicles were based on findings of a previously issued report (2). Thus, for the roadway, traffic flow conditions consisting of vehicle type, volume, and speed were input into the model. The STAMINA 2.0 User's Manual (1) did not specify what speeds were to be used. The 85th-percentile speed, which is the speed used to set speed limits, was used in this study.

A model of the roadway was constructed mathematically using a three-dimensional coordinate system to describe a string of sequentially connected straight-line segments. This presented a complex situation because the roadway running in each direction consisted of a mainline and an entrance or exit ramp, all within the study site location. It was decided to model the ramps, the mainline section before the ramp, and the mainline section after the ramp all as individual roadways with corresponding traffic volumes. For example, the southbound lanes of I 471, which are adjacent to the noise barrier, are comprised of the mainline section and an entrance ramp. The ramp was considered as one roadway and its traffic volumes recorded. The mainline section just prior to the entrance ramp was considered as a separate roadway and its traffic volumes recorded. Finally, the mainline section just past the entrance point of the ramp was considered as a roadway itself; the ramp traffic volumes and the previous mainline section volumes were added to obtain combined traffic volumes for the third roadway. A similar technique was used for the northbound lanes. The exit ramp and mainline section traffic volumes were added to obtain combined traffic volumes for the section just prior to the exit ramp. Thus, there were three individual roadways for each direction, or a total of six. The individual roadways making up the northbound or southbound roadways contained common terminal points in order to connect the individual sections. STAMINA 2.0 allows the user to adjust the emission levels for heavy trucks moving up grades, but does not allow the user to define traffic flow direction. However, a grade adjustment factor may be included in the roadway model and was taken into account in the prediction process for the upgrade southbound lanes.

The noise barrier was modeled physically in the same manner as the roadway, using a three-dimensional coordinate system to describe the barrier as a string of sequentially connected straight-line segments. Both ground elevation and barrier height coordinates were entered into the model. It was decided to model the concrete median barrier as a noise barrier. Though it is not intended to be used as a noise barrier and its effect would be minimal at best, it was decided to include the concrete median barrier in the model in an attempt to approximate the actual site as closely as possible by the model. For the same reason, the large hill located adjacent to the southbound lanes at the north end of the noise barrier was included in the model as an earth barrier. STAMINA 2.0 recognizes three types of barriers: absorptive, reflective, and structural barriers. Both the noise barrier wall and the concrete median barrier were considered to be reflective barriers, while the earth barrier was considered to be absorptive.

Other factors recognized by STAMINA 2.0 in the modeling process are alpha factors, which concern the effect of hard or soft ground on the noise propagation rate between the source and receiver, and shielding factors, which account for the additional attenuation of noise due to shielding by buildings, rows of houses, trees, or other terrain features. The hillside behind the noise barrier was covered thickly with vegetation, leading to the use of the 4.5 dB per distance doubling propagation rate for soft ground between the roadway and the study site microphone. A propagation rate of 3 dB per distance doubling was used for the hard pavement surface between the roadway and the reference microphone. There were no shielding factors between the roadway and reference and study site microphones to cause additional noise attenuation in the model calibration process.

Noise measurements were taken at the reference microphone location by placing a microphone atop the 28-foot tripod and connecting it via cable to a B & K Model 4426 Noise Level Analyser. The microphone at the study site was supported on a smaller 5-foot tripod and was connected to another B & K Noise Level Analyser.

The final step in the calibration process was to obtain noise measurements at the selected microphone reference and study site locations. During this time period, traffic volumes and speeds were recorded. Using recorded traffic volumes and speeds, noise levels at the two receiver locations were predicted by the STAMINA 2.0 program. Those levels were then compared to the actual recorded levels at the receiver locations for the same time periods in order to test the validity of the model.

INSERTION LOSS MEASUREMENTS

After calibration of the STAMINA 2.0 model, initial tests were performed to estimate the barrier insertion loss. Study site locations were selected throughout the neighborhood and "after" noise level measurements were obtained at these locations using a B & K Noise Level Analyser. Noise level measurements were made at 10-minute intervals and corresponding traffic volumes were recorded. To obtain the "before" noise levels, the x, y, and z coordinates of the receiver locations were input into the STAMINA 2.0 model as described in the model calibration. Appropriate alpha and shielding factors were also input. Coordinates of the noise barrier were excluded from the model to simulate the situation that would exist when there was no noise barrier. Corresponding traffic volumes were input into STAMINA 2.0 and the model was used to predict the noise levels that would exist for the study site receiver locations if the noise barrier did not exist. The barrier insertion loss for each receiver location was calculated to be the difference between the "before" and "after" noise levels.

RESULTS

MODEL CALIBRATION RESULTS

To calibrate the model, noise level measurements were obtained and corresponding traffic volumes and speeds were recorded for the reference location and the initial study site location. Data were collected over seven 10-minute intervals, resulting in seven separate "runs". For each run, the traffic volumes and speeds were entered into the STAMINA 2.0 model; the model used those volumes and speeds to predict what the noise level might be. That was compared to actual recorded traffic noise emission levels. For the reference microphone location, the allowable difference in Leq could not be more than 1.0 dBA. For seven runs, the average difference in Leq was 0.83 dBA. The difference ranged from 0.2 to 1.6 dBA. The average difference in L10 at the reference microphone was 0.2 dBA with a range of 0.0 to 0.5 dBA.

The allowable difference in Leq for the study site microphone location was 2.0 dBA. For seven runs, the average difference was 0.86 dBA, which also was acceptable. The difference ranged from 0.2 to 2.0 dBA. The average difference in L10 at the reference microphone was 0.9 dBA with a range of 0.0 to 2.3 dBA. Therefore, it was assumed that the STAMINA 2.0 model of the noise barrier site was calibrated properly and could be used to predict traffic noise levels for the situation where no noise barrier existed.

INITIAL FIELD MEASUREMENTS

A series of initial field tests was conducted to estimate the noise barrier insertion loss. Receiver locations were selected throughout the residential neighborhood (Figure 4) and noise level measurements were obtained at those locations. Noise level measurements were taken over 10-minute intervals as corresponding traffic volumes and speeds were recorded. Results of the initial field measurements are listed in Table 1. The measured Leq and L10 noise levels are compared to the Leq. and L10 noise levels predicted by STAMINA 2.0 that would exist if no noise barrier were present. The insertion loss is the difference between the measured existing noise levels and the predicted noise levels assuming no noise barrier was present.

Initial field measurements were taken at 20 locations throughout the neighborhood. Due to difficulty in modeling the undulating topography at Receiver No. 1 and due to the fact that the receiver was located beyond the end of the noise barrier, a barrier insertion loss for Receiver No. 1 could not be estimated accurately. For the remaining locations, the average barrier insertion loss in Leq was 7.0 dBA, ranging from 3.5 dBA at Receiver No. 8 to 13.0 dBA at Receiver No. 5. The average barrier insertion loss in L10 was 8.2 dBA, ranging from 5.0 dBA at Receiver No. 2 to 14.3 dBA at Receiver No. 5. The barrier insertion loss for each receiver location was a function of the topography of the study site, including noise attenuation provided by houses and vegetation. It was not dependent solely on the horizontal distance between each receiver and the traffic noise barrier.

SURVEY OF COMMUNITY PERCEPTION

A survey of community perception of the barrier will be conducted as part of the final phase of the study. The survey will be in the form of a questionnaire and accompanying cover letter explaining the purpose of the survey. The letter and questionnaire, along with a postage-paid return envelope, will be distributed by hand to all residences that are determined to be affected by the noise barrier.

The questionnaire consists of common questions asked of residents in similar noise barrier evaluation projects (3, 4, 5, 6, 7, 8). Questionnaire topics include awareness of the barrier, highway-related problems with the barrier, activities affected by the barrier, and the general effectiveness of the noise barrier as perceived by residents of the neighborhood. The cover letter and questionnaire are contained in the Appendix.

FUTURE DATA COLLECTION

Data will be collected periodically at the I 471 barrier site through the spring of 1985. Sufficient data will be obtained so that noise contours may be estimated. In addition to collection of noise data, the community perception survey will be conducted. Questionnaires will be hand delivered to those residences considered to be affected by the noise barrier.

At the end of the data collection task, a final report will be prepared. Noise data will be analyzed and the barrier insertion loss will be determined. Results from the questionnaire survey will be tabulated and summarized. The final report will detail the effectiveness of the noise barrier and make recommendations concerning construction of future noise barriers.

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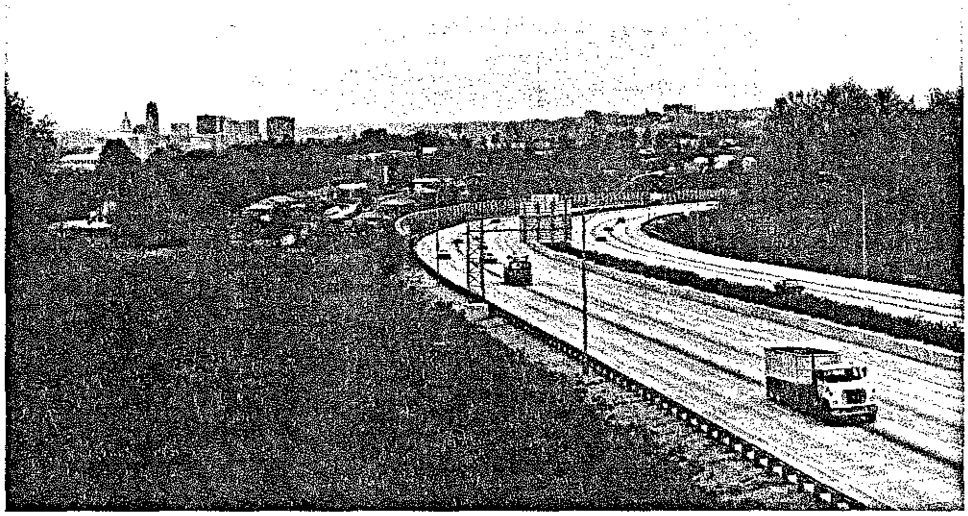

Figure 1. Noise Barrier, Interstate 471, Campbell County, Kentucky.

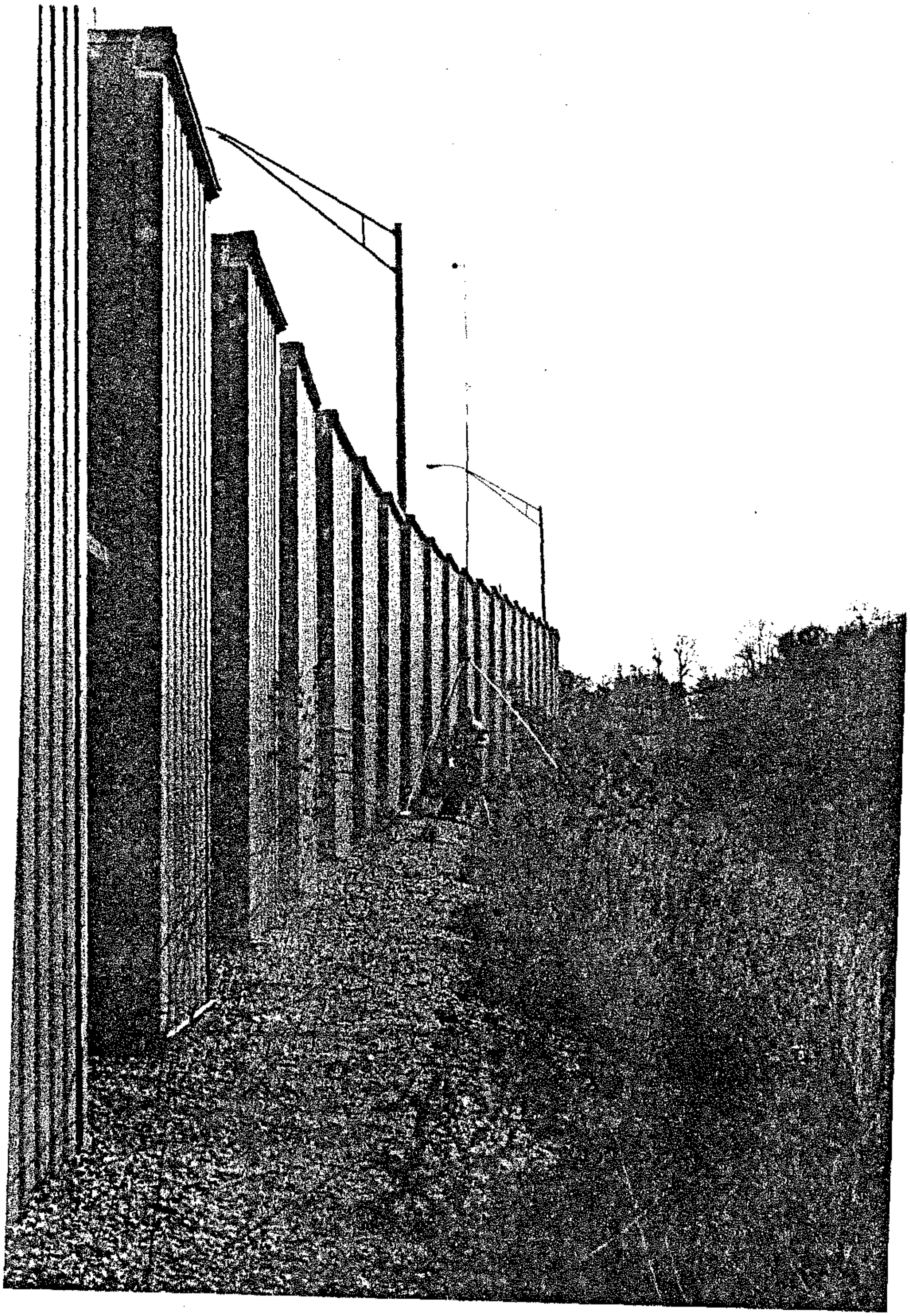

Figure 2. Elevated Reference Microphone.

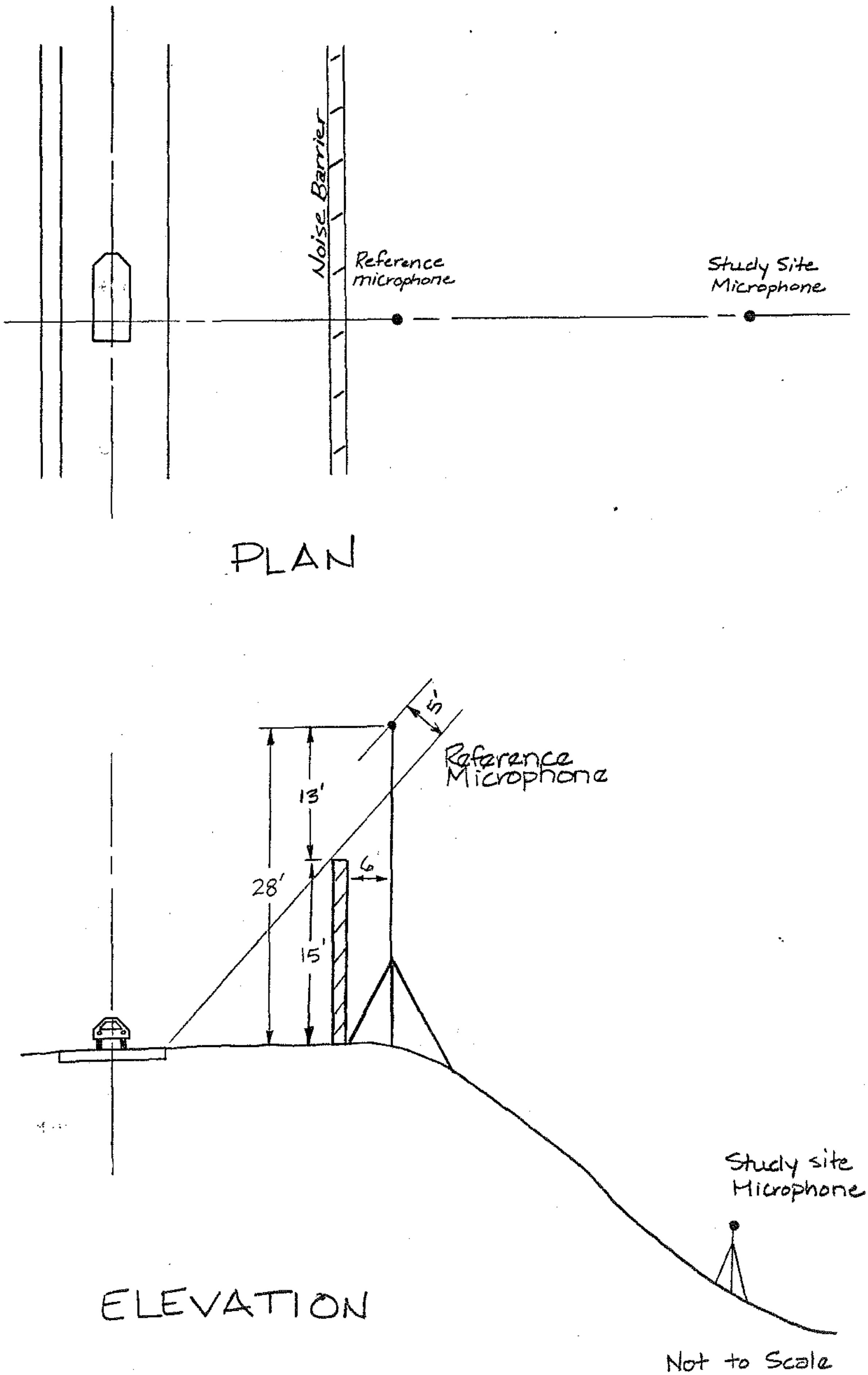

Figure 3. Reference Microphone Positioning.

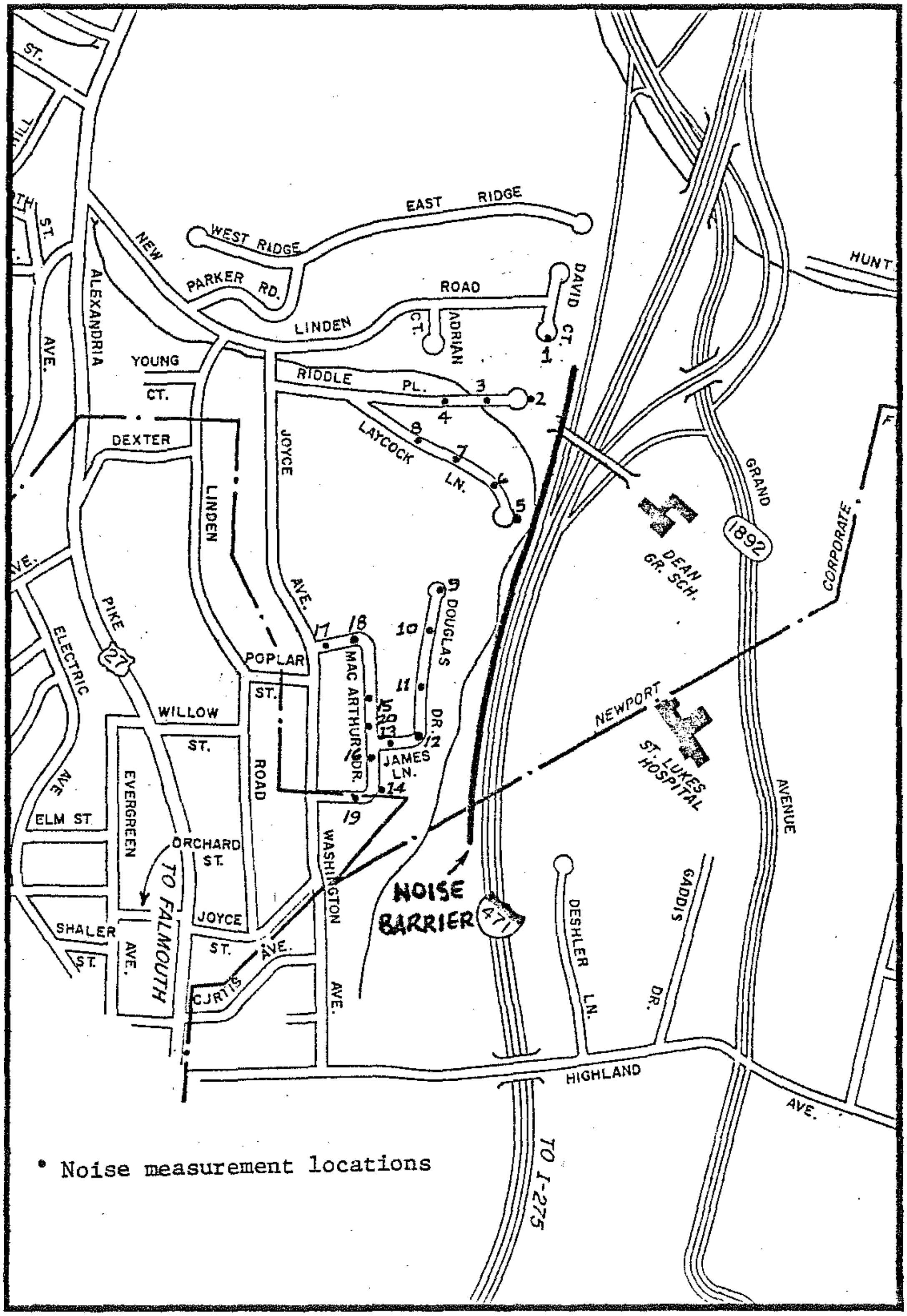

Figure 4. Initial Field Measurement Receiver Locations.

TABLE 1. INSERTION LOSS MEASUREMENTS

RECEIVER LOCATION NUMBER	MEASUREMENT NUMBER	MEASURED NOISE LEVEL Leq	MEASURED NOISE LEVEL L10	PREDICTED NOISE LEVEL* Leq	PREDICTED NOISE LEVEL* L10	INSERTION LOSS** Leq	INSERTION LOSS** L10
1	1	51.2	53.5	----	----	----	----
	2	51.7	54.5	----	----	----	----
2	1	54.6	57.0	58.4	62.0	3.8	5.0
	2	54.0	54.0	58.7	62.2	4.7	6.2
3	1	49.6	51.5	56.0	59.6	6.4	8.1
	2	50.5	53.0	56.1	59.6	5.6	6.0
4	1	51.1	53.8	55.1	58.6	4.0	4.8
	2	50.3	52.5	55.8	59.2	5.5	6.7
5	1	54.9	57.8	66.4	69.8	11.5	12.0
	2	52.3	54.5	65.3	68.8	13.0	14.3
6	1	54.1	56.5	61.6	64.9	7.5	8.4
	2	53.1	55.8	61.2	64.5	8.1	8.7
7	1	49.6	52.0	56.2	59.7	6.6	7.7
	2	50.4	52.5	55.8	59.2	5.4	6.7
8	1	51.9	53.8	55.9	59.3	4.0	5.5
	2	52.0	53.0	55.5	58.9	3.5	5.9
9	1	52.3	54.0	60.7	64.3	8.4	10.3
	2	50.8	52.0	60.0	64.1	9.2	12.1
10	1	54.6	57.0	59.3	62.8	4.7	5.8
	2	53.5	55.8	60.2	63.7	6.7	7.9
11	1	52.6	55.0	60.8	64.4	8.2	9.4
	2	53.4	55.8	61.1	64.7	7.7	8.9
12	1	54.7	56.3	65.2	68.3	10.5	12.0
	2	54.5	56.5	64.6	67.9	10.1	11.4
13	1	52.9	55.3	59.3	62.5	6.4	7.2
	2	53.0	56.3	59.8	63.1	6.8	6.8
14	1	55.2	57.3	61.6	64.7	6.4	7.4
15	1	48.5	50.8	56.1	59.6	7.6	8.8
	2	50.4	54.0	56.2	59.7	5.8	5.7
16	1	52.2	54.3	57.9	61.2	5.7	6.9
	2	52.1	54.0	58.8	62.1	6.7	8.1

17	1	45.3	48.0	52.8	56.4	7.5	8.4
	2	46.7	49.3	53.1	56.7	6.4	7.4
18	1	46.6	49.5	53.9	57.4	7.3	7.9
	2	45.7	48.0	53.7	57.3	8.0	9.3
19	1	52.3	53.3	57.3	60.6	5.0	7.3
20	1	47.8	49.8	55.9	59.4	8.1	9.6
	2	47.9	49.5	57.1	60.5	9.2	11.0

*Predicted using STAMINA 2.0 assuming no noise barrier present.
**Insertion Loss = Predicted noise level - Measured noise level.

APPENDIX

Cover Letter and Questionnaire

KENTUCKY TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

College of Engineering
Transportation Research Building
533 South Limestone
Lexington, Kentucky 40506-0043
Telephone: 606-257-4513

Dear Resident:

The University of Kentucky Transportation Research Program, in conjunction with the Kentucky Transportation Cabinet, is conducting a research study to evaluate the effectiveness of the traffic noise barrier located on Interstate 471 in Campbell County. As part of this study, it is important to obtain the opinion of the affected residents concerning the noise barrier.

Enclosed is a questionnaire and a self-addressed, postage-paid return envelope. Please fill out the questionnaire and return it at your earliest convenience. All information will be kept confidential. Information from the questionnaires will be used in determination of traffic noise barrier effectiveness and as an aid in future decisions regarding location and construction of noise barriers. Thank you for your assistance.

Sincerely,

Tom Creasey

Tom Creasey
Transportation Research Engineer

TRANSPORTATION RESEARCH PROGRAM

UNIVERSITY OF KENTUCKY

EFFECTIVENESS OF TRAFFIC NOISE BARRIERS QUESTIONNAIRE

Please complete and return this questionnaire in the enclosed self-addressed, postage-paid envelope. Thank you for your cooperation.

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1. How long have you lived at this address? ____Years ____Months

   What is your street address: ______________________________

2. How many persons live at this residence? ________

3. Do you own your residence, or do you rent? ___Own ___Rent

4. How would you describe your neighborhood before and after construction of I 471 and the accompanying traffic noise barriers?

	Before Construction (Check one)	After Construction (Check one)
Very quiet	_____	_____
Quiet	_____	_____
A little noisy	_____	_____
Noisy	_____	_____
Very Noisy	_____	_____

5. Are you aware that a noise barrier, which was constructed at the same time as I 471, stands between your residence and the interstate? ____Yes ____No

   (If you answered "No" to the above question, please stop here and return the questionnaire; if you answered "Yes", please continue).

6. How did you learn about the noise barrier?

__________Television/Radio
__________Newspaper
__________Public hearing notice
__________Letter from a political representative
__________Observed construction of barrier
__________Other ______________________________

7. How do you feel that the presence of a noise barrier has affected these highway-related problems compared to the situation where no noise barrier was present?

	Worse	No Effect	Slight Improvement	Significant Improvement	No Opinion
Highway dust and dirt	____	____	____	____	____
Headlight glare	____	____	____	____	____
Litter from vehicles	____	____	____	____	____
Highway noise	____	____	____	____	____
Road vibration	____	____	____	____	____
Road fumes	____	____	____	____	____
Privacy	____	____	____	____	____
Other________	____	____	____	____	____

8. How do you feel that the presence of a noise barrier affects the following activities compared to the situation where no noise barrier was present?

	More Difficult	No Effect	Less Difficult	Significantly Less Difficult	No Opinion
Conversation indoors	____	____	____	____	____
Conversation outdoors	____	____	____	____	____
Telephone use	____	____	____	____	____
Relaxing indoors	____	____	____	____	____
Relaxing outdoors	____	____	____	____	____
Sleeping	____	____	____	____	____
Leaving windows open	____	____	____	____	____
Other________	____	____	____	____	____

9. Indicate if you feel that the noise barrier has created any of the following disadvantages:

	Yes	No	No Opinion
Creates closed-in feeling	______	______	______
Hurts area environment	______	______	______
Limits or restricts view	______	______	______
Requires more yard maintenance	______	______	______
Visual eyesore; unsightly	______	______	______
Other____________________	______	______	______

10. How do you feel about the appearance of the barrier?

______Attractive ______OK ______Unsightly

11. Compared to having no noise barrier at all, how effective do you feel the noise barrier has been in reducing the traffic noise?

______Very Effective ______Somewhat Effective ______No Effect

12. How do you feel the presence of the noise barrier has affected the value of your property?

______Decreased Significantly ______Decreased Somewhat ______No Effect ______Increased Somewhat

13. If the noise barrier had not been built, do you feel that you would use your yard more, less, or the same amount?

_____More _____Less _____Same Amount

14. How do you feel about the noise barrier in general?

_____Like _____Dislike _____No Opinion

Please feel free to submit any further comments about the noise barrier here. Thank you. Your help is sincerely appreciated.

____
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