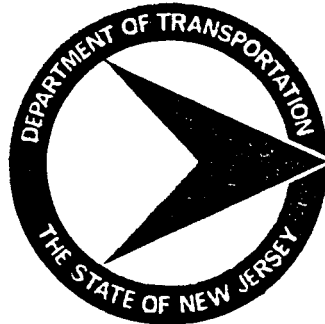


**DETERMINATION OF INSERTION LOSS
FOR TRAFFIC NOISE BARRIER
ALONG I-676 CAMDEN, N.J.**

**BY
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16. Abstract Traffic noise data was collected at a site adjacent to I-676 in Camden, N.J. in order to determine the insertion losses resulting from a noise barrier constructed along the northbound side of the highway. The barrier was a concrete post-and-panel structure placed atop a concrete parapet to give an effective height of ten feet. Data was collected using five microphones: a reference microphone was placed at the barrier and five feet higher than its top, in order to eliminate interference from the barrier; one set of field microphones (one at five feet and one at ten feet) was placed 150 feet from the reference microphone; a second set of field microphones at the same heights was placed 300 feet from the reference microphone. All positions were along a line perpendicular to the highway. Noise data, traffic counts, and speeds were all recorded simultaneously. Observations were nominally six minutes long. The noise observations were later edited to remove extraneous noise so that the final samples contained only four-minute observations of "clean" traffic noise. Traffic counts were prorated to four minutes. Since it was not possible to obtain or to simulate data from before the barrier was constructed, it was necessary to use predicted levels to determine insertion losses. STAMINA 2.0, the current design model at NJDOT, was first tested by comparing predicted levels with those obtained from field measurements. The predicted data proved to be acceptably close to the field data for all microphone positions, so the predicted "before" and predicted "after" data sets were used to find the insertion loss at each. Analysis of the data by non-parametric statistical methods yielded insertion losses and confidence limits of 4.3 to 7.2 dB, ± 0.4 , the lower figure being for the microphones placed at 300 feet from the barrier.					
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SUMMARY AND CONCLUSIONS

Traffic noise data was collected at a site adjacent to I-676 in Camden, New Jersey in order to determine the insertion loss of a concrete post-and-panel noise barrier erected there. This barrier was placed atop a parapet, giving it an effective height of ten feet. In addition to the noise data, traffic counts were kept for traffic on both sides of the highway, and radar speed readings were recorded for near side traffic. Five microphones were situated at three different locations. A reference microphone was placed at the barrier on a fifteen-foot mast, to eliminate any effect the barrier might have on the sound. Two field microphones, one at five feet and another at ten feet above ground level were placed at 150 feet from the barrier; a second pair was placed at 300 feet from the barrier. See Figures 1 and 2, pages 10 and 11 for diagrams of the data collection site.

As with previous studies in highly urbanized areas, much of the highway traffic noise was interspersed with traffic noise from local streets, and noise from trains, airplanes, industrial and commercial operations, and nearby houses. Consequently initial observations were nominally six minutes long, to be edited later to remove non-highway generated noise. The "clean" four-minute observations were then reduced to obtain an L_{eq} for each.

Since the barrier was already in place at the time of the study, it was not possible to obtain "before" data, nor was it possible to find a similar site without a barrier, to simulate the "before" condition. Thus it was necessary to predict the "before" condition using the traffic data from the "after" condition in STAMINA 2.0. The first step in this procedure was to predict the "after" levels using "after" traffic counts, and then compare the predicted results with those determined from the field measurements. The two sets of data were compared by finding the best fit curve for the measured "after" data versus the predicted "after" data for each microphone

position. In all five cases the best fit was a straight line with a slope of 1; only the constant (x-intercept) differed in each case. This showed that the model predicted uniformly for all microphone positions, but that the predicted data differed from the data derived from field measurements by a constant amount, which varied according to microphone position. This constant, when added to each of the "measured after" data points for a particular microphone position, would have made these data points coincide with those resulting from the prediction method. Stated another way, each particular constant was a measurement of the prediction error for one specific microphone position. However, the primary concern was not with the precision of the prediction method, but with the general form of the relationship between corresponding data sets, and their comparison to the analogous relationships discussed below.

The next step was to predict the "before" data for each microphone and then determine the relationship between these data sets and those from the already predicted "after" data. The best-fit curve for each microphone position was again a straight line with a slope of 1, differing only in the constants. Thus corresponding pairs of curves were parallel to each other, obviating the need for a correction factor. (See Figure 4, page 17.) Had the two curves for LIPI (for example) been divergent (or convergent), it would have been necessary to apply a correction factor to the predicted "before" and the predicted "after" data actually used to determine the insertion losses. But since all ten best-fit curves were straight lines with the same slope, it was logically assumed that the predicted "before" and "after" data sets could be used to determine insertion losses without a correction factor. This was supported by the fact that the constants in the "measured after" versus the predicted "after" cases were rather small, which indicated (acceptably) close agreement between the data sets, for each microphone position. The constants for the predicted "after" versus the predicted "before" data sets are large by comparisons, indicating a

considerable difference in the two sets of data for each microphone. This was exactly what was desired; the relatively large constant in each case was approximately the insertion loss at that particular microphone position.

It was perfectly reasonable to use the differences in predicted levels to find the insertion losses, since these are the result of the "before" and "after" differences rather than the absolute values. When the insertion losses were actually determined (using the techniques described below), the fact that all ten lines were parallel eliminated any need to apply a correction factor. A complete description of the data analysis methods is contained in the Data Analysis section.

All of the sets of predicted levels were tested for normality, the result being that some tested as not being normally distributed. The (predicted) data was therefore analyzed using non-parametric methods to obtain the insertion losses and associated confidence limits at each microphone position. The only difference between the "before" and "after" conditions was the placing of the barrier in the sound path. The same traffic counts (the actual "after" counts obtained during data collection) were used for both sets of predictions. The first estimate of the insertion loss at any one position was taken to be the difference between the "before" median level of the predicted data, and the "after" median level. To test the accuracy of this first estimate, the difference in medians was added to each data point of the predicted "after" data for the particular position. This modified "after" data was then tested to see if it was from the same population as the predicted "before" data for that position. For each of the four field positions, the test showed that the two sets of data were from the same population. The first estimates were then adjusted slightly to obtain a "best fit," that is, the two data sets for each microphone were made to coincide as nearly as possible. This "best fit" difference was then considered to be the insertion loss in each case. Confidence limits for the 95% level were then calculated for each of these insertion losses. The insertion losses thus determined were from 4.3 to 7.2 dB, ± 0.4 . The complete listing is shown in Table III, page 19.

Two conclusions may be drawn from the data analysis described above. First, STAMINA 2.0 correctly predicted "after" levels for each microphone position, which were in linear relationship to the "measured" levels, and differed from them only by a small constant in each case. Furthermore, all of these relationships had the same slope. This allowed for the use of the predicted "before" and "after" levels in determining insertion losses. Second, the barrier is moderately effective in reducing traffic noise, even at a distance of 300 feet from the structure.

RECOMMENDATIONS

The following recommendations are based on the analysis of data for this project and its results.

First, the barrier can be recommended as an acoustically effective and structurally sound noise control device. When constructed the concrete post-and-panel design provides a continuous, leak-proof barrier which will last indefinitely and cannot be damaged unless it is hit by a vehicle. In this particular instance it is highly unlikely that this would occur, since the barrier is at the berm edge of the shoulder and is placed atop a bridge parapet for much of its length. The parapet plus the barrier gives an effective barrier height of ten feet, which is the only fault to be found with this particular barrier as built; it is not high enough. The exhaust stacks of many of the larger trucks on the highway could be seen from the field microphone positions, demonstrating clearly that the barrier was to a great extent ineffective in reducing the exhaust noise from these vehicles. It is therefore recommended that future barriers be constructed high enough to block the noise from the stacks of these larger trucks.

Second, prior to noise data collection on any highway, preliminary observations should be made to determine such things as traffic patterns and mixes, and speeds. Obviously there are certain times of day and certain seasons (in some cases) when the percentage of light vehicles is far greater than at other times. Care must be taken to avoid biasing a sample toward these occurrences, and to obtain a sample which is representative of the general conditions. Observation length should also be determined during this preliminary study period, again to be certain that each observation (and thus each sample) is representative of the general conditions. One aspect of determining observation length is the interference of non-traffic noise sources, especially when working in highly urbanized areas. Observation length must

be adequate to allow for editing out this extraneous noise while at the same time yielding an observation of "clean" noise which is representative of the general conditions.

Third, samples should consist of 35-45 observations after editing is completed, which qualifies each sample as a "large" sample so that small sampling techniques need not be considered in performing the analysis. This requires an initial sample of about 50-60 observations, which requires only about eight working days for the worst-case conditions. This relatively small sample also minimizes data reduction time.

Fourth, in cases where either the "before" or "after" data must be predicted either of the sample sizes (35-45 edited or 50-60 unedited observations) may be used, since the prediction process is not affected by non-traffic noise. However, complete traffic data must be available for each observation. In determining the relationship between predicted and "measured" levels the best comparison will probably be made if only the predicted levels which correspond to the "measured" levels are used. However, this will depend upon the method chosen. In determining insertion losses, all observations for which there are complete traffic counts and speeds may be used, since the prediction process is in no way affected by non-traffic noise. Thus, "more complete" (but not overly large) samples can be made available, and if used will yield higher confidence limits.

INTRODUCTION

The purpose of this study was to determine barrier insertion losses along I-676 northbound in Camden, New Jersey. The barrier was mounted on a concrete parapet along much of its length, the total height of the two structures being ten feet. Each section consisted of concrete panels supported by concrete H-beams on eighteen-foot centers. A total of almost 8500 linear feet of this barrier was constructed, at a cost of almost \$1,122,000, exclusive of the parapet.

The roadway at the data collection site was typical of most of the highway in that there was a noise barrier on the northbound side only, there was a 24" x 41" high (overall) New Jersey concrete barrier curb, and the roadways were elevated on embankment or bridges. Although there was increased loading of the bridges by the barrier, this added very little to their cost (.3% or less). The combined width of the roadways and shoulders was 120 feet, for several hundred feet on either side of the site.

At the time of the study the noise barrier was already in place, and there was no comparable barrier-free location along the roadway. Consequently it was not possible to collect "before" or even simulated "before" noise data. It was first necessary to compare the "after" levels as determined from the reduction of field measurements, with "after" levels predicted by STAMINA 2.0, using the actual traffic counts taken during the "after" measurements. These two sets of data were found to be in close agreement. It was therefore assumed that the predicted "before" levels would also have been equally close to "before" levels derived from field measurements, had there been any. Thus the actual analysis performed to find the insertion losses for each microphone position was performed on predicted levels, rather than on levels from reduced field measurements.

STUDY PROCEDURES

DATA COLLECTION

Traffic noise data was recorded simultaneously from five microphones placed along a line perpendicular to the roadway, at three locations. The equipment and locations are described below.

Reference: A 1/2" free field B & K microphone was mounted on a 15-foot mast, which placed it five feet higher than the barrier in order to eliminate any effects from the barrier top. The microphone was connected by cable to a 2218 B & K sound level meter, from which an L_{eq} for the total time of the observation could be read directly. The microphone and mast were placed immediately adjacent to the barrier on the source side. This location will be designated as R in the text.

Location 1: Two 1" B & K microphones were placed on tripods, one set at five feet and the other at ten feet above ground level. These were connected by cables to B & K sound level meters, which in turn were connected to a Nagra Type IV-SJ tape recorder. This location was 150 feet from the source side of the barrier. The five-foot microphone will be designated L1P1 (Location 1, Position 1) and the ten-foot one will be L1P2 (Location 1, Position 2) in the text.

Location 2: Two 1" microphones on two tripods were set up as described above. They were connected by cables directly to a Nagra Type IV-SJ tape recorder equipped with sound level meters. These microphones are designated L2P1 and L2P2 in the text. Location 2 was 300 feet from the source side of the barrier.

Random incidence correctors were used on the 1" microphones; windscreens and dessicators were used on all microphones. Figures 1, 2, and 3, pages 10, 11, and 12 show the layout of equipment on the site and in the van. Because of the high incidence of non-traffic noise, observations were nominally six minutes long, to be later edited to four minutes during data reduction. Since the recording tapes were 45 minutes long,

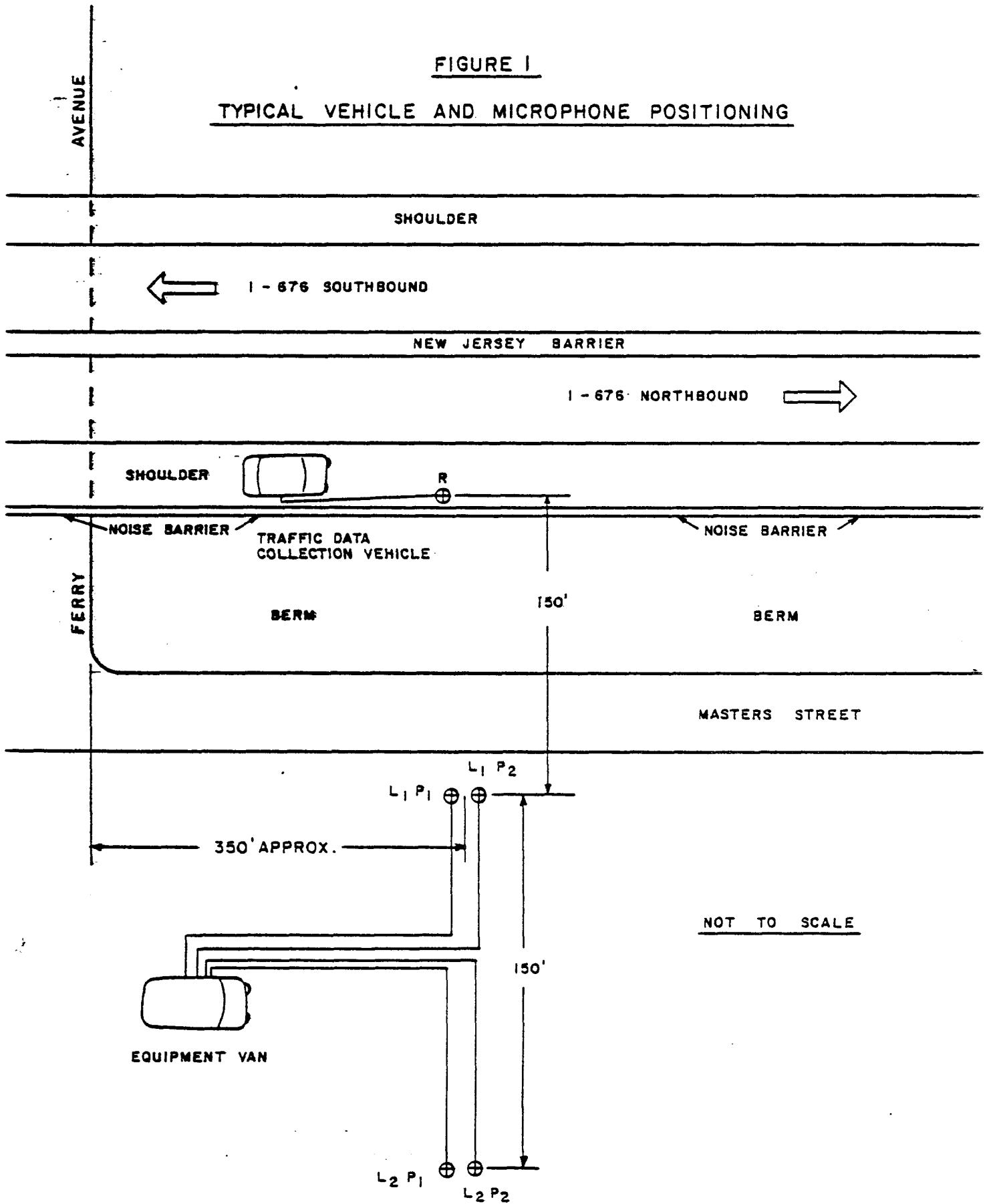
this allowed time for seven six-minute observations on each channel simultaneously, while leaving adequate room for calibration signals and voice announcements. The L_{eq} recorded at R however was for four minutes only, because there was no way to edit out the extraneous noise afterwards. Careful and detailed field notes were kept on noise from planes, trains and other sources which could have affected the readings at this microphone position. Those observations which might have been so affected were discarded prior to data analysis. Appendix I, page 22 gives a detailed description of the data collection routine.

In addition to the recording of traffic noise, a vehicle count was kept for both the northbound and southbound roadways, for the duration of each six-minute observation. This count was broken down into light vehicles, medium trucks, and heavy trucks. A minimum of ten radar speed observations were also recorded for nearside traffic during each observation. Wind speed and direction, and ambient temperature were recorded at the start of each tape, and at least two more times while the tape was running.

A total of 66 observations was made, but already noted many of these had to be discarded during the data reduction process. Table I, page 16 shows the actual number of observations from each microphone which were useable in the data analysis operation.

FIGURE 1

TYPICAL VEHICLE AND MICROPHONE POSITIONING



NOT TO SCALE

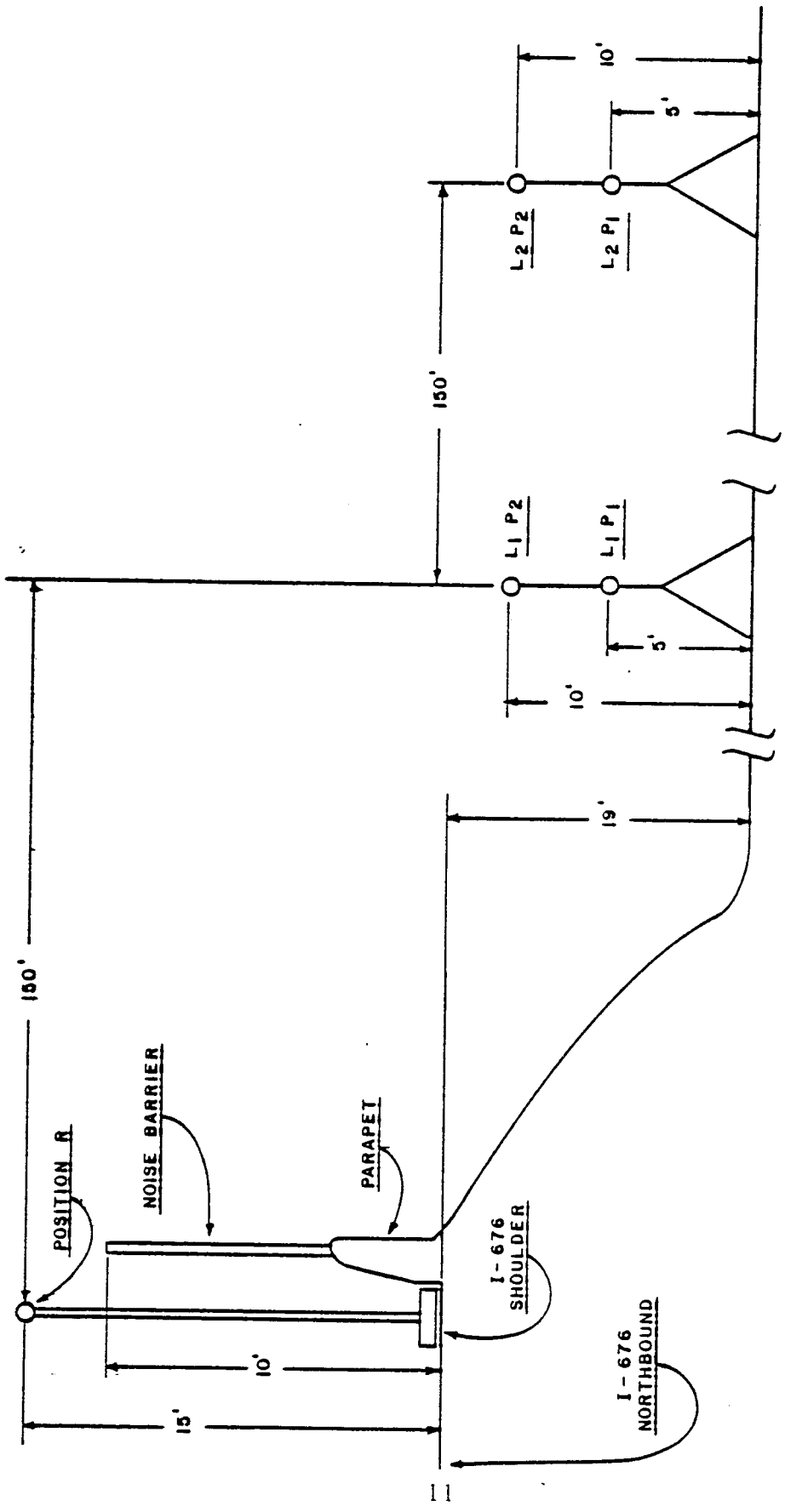
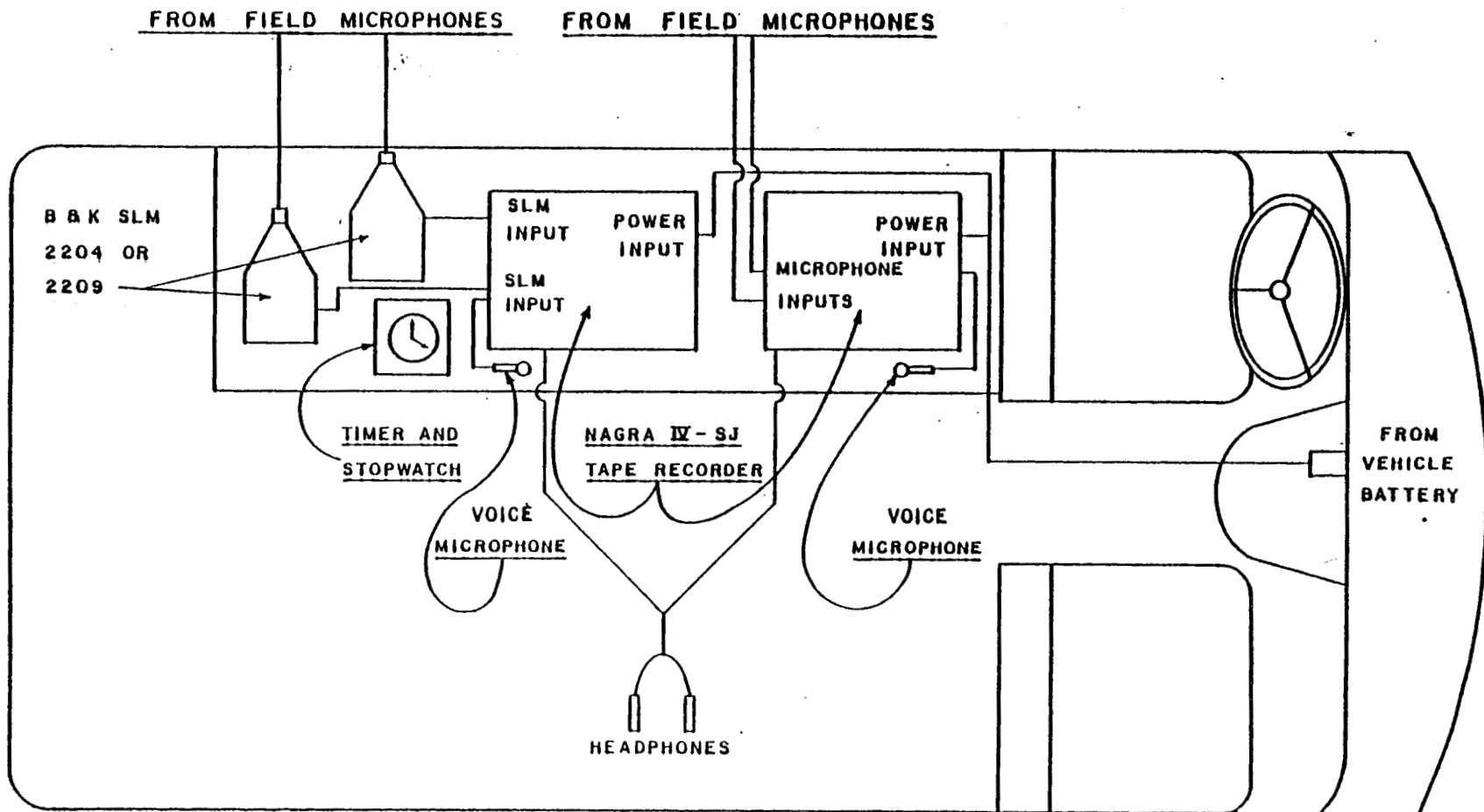


FIGURE 2
MICROPHONE LOCATIONS AND ELEVATIONS

NOT TO SCALE



12

NOT TO SCALE

FIGURE 3

DATA COLLECTION EQUIPMENT LAYOUT

DATA REDUCTION

Data reduction had two purposes; specifically, the editing out of extraneous noise, and obtaining an L_{eq} for a four-minute edited observation containing "clean" traffic noise. This required two reduction runs for each observation. The first run was used to edit the recording using the graph from the B & K Graphic Level Recorder, voice announcements from the tape, and the actual non-traffic noise itself as recorded on the tape. The non-traffic noise portions of the observation were discarded and only the "clean" traffic noise was used for the second run, which was routed through a 2218 B & K Sound Level Meter to give an L_{eq} for a four-minute portion of the "clean" noise. Observations which did not have a four-minute clean portion were discarded prior to data analysis. A complete description of the data reduction process is in Appendix II, page 22. Another part of data reduction was the prorating of the traffic counts from those obtained for the entire duration of the original observation, to counts which corresponded to the final four-minute observations obtained from editing. In those cases where no four-minute observation could be obtained for any of the five microphone positions, the traffic counts were discarded and not used in the prediction process.

The last item of data reduction was obtaining the average speed for each useable four-minute observation, from the total number of observations made during the original six-minute (nominal) field observation. Prorating the number of speed observations to correspond to the reduction in noise observation duration resulted in virtually no change in the average speed. Therefore the entire number of speed observations was used in each case to calculate the average.

DATA ANALYSIS

The first step in data analysis was to predict L_{eq} 's for those observations for which a measured L_{eq} had been obtained. This was done using STAMINA 2.0, the design model currently in use at NJDOT. Input data included the prorated traffic counts for each useable four-minute observation which were extrapolated to one hour, the average speed for each of these, and the geometry of the roadway and microphone layout. Once the predicted data was obtained, it was compared to the "measured" data to determine how closely the two corresponded. The comparison was made by taking pairs of data sets (e.g., LIP1 "measured" and LIP1 predicted) and finding the best fit curve for each pair. The first step in this process was to construct a difference table for the (x,y) pairs of L_{eq} 's. The "measured" levels were designated x, and the predicted were designated y. The difference table showed that the second differences became constant, indicating that a quadratic would be the highest degree equation applicable to determine the relationship between x and y. Thus the form $y = ax^2 + bx + c$ was used. For each of the five pairs of data sets the x^2 term disappeared, leaving only the straight line form $y = bx + c$. Furthermore, the slope b was in each case equal to 1, so that the five lines were parallel and differed only in the constants (the x-intercepts) which were small. Thus it was shown that the relationship between the "measured" and predicted "after" data was essentially the same at each of the five microphone positions.

Next the "before" data was predicted from the same traffic data and geometry as used for the "after" predictions, and a difference table constructed for the (x,y) pairs as before. Again the quadratic term disappeared leaving only the straight line form for all positions, and again the slope of these lines was 1. Therefore the lines representing the predicted "after" vs. "before" data for each microphone were parallel to those representing the "after" predicted vs. measured data. Since insertion loss is a

function of "before" and "after" differences rather than of absolute values it was possible to use the predicted values to determine them, and since the two sets of lines were parallel, it was possible to do so without applying any correction factor.

Table I, page 16 shows the various sample sizes used in determining the relationships described above. Table II, page 16 lists the actual equations. Figure 4, page 17 shows the sets of lines determined at this stage of the analysis. Had there been variations in the slopes of the lines, or in forms, correction factors would have had to have been determined and applied. The constants (x-intercepts) in each case are close to the differences in medians of each of the predicted data set pairs for the "before" and "after" conditions.

To actually determine the insertion losses for any one of the four field microphones, the difference in medians between the predicted "before" L_{eq} 's and the predicted "after" L_{eq} 's was added to each of the "after" data points. This modified "after" data set was then tested, using the Wilcoxon Rank-Sum test, to determine if it was from the same population as the "before" data set.⁽¹⁾ If the test showed this to be the case, the difference that had been applied was taken as a first estimate of the insertion loss for that microphone. Each estimate was adjusted if necessary to obtain a "best fit" for the particular data set pairs. This adjusted difference was then assumed to be the insertion loss, insofar as could be determined from the available data. Confidence limits at the 95% level were also calculated, using a method associated with the Wilcoxon Rank-Sun test. Table III, page 19 shows the insertion losses and confidence limits found for each of the field microphones.

⁽¹⁾ See Reference (1) for a relatively brief discussion on application, and Reference (6) for a more theoretical and complete discussion.

TABLE I
SAMPLE SIZES USED IN DATA ANALYSIS

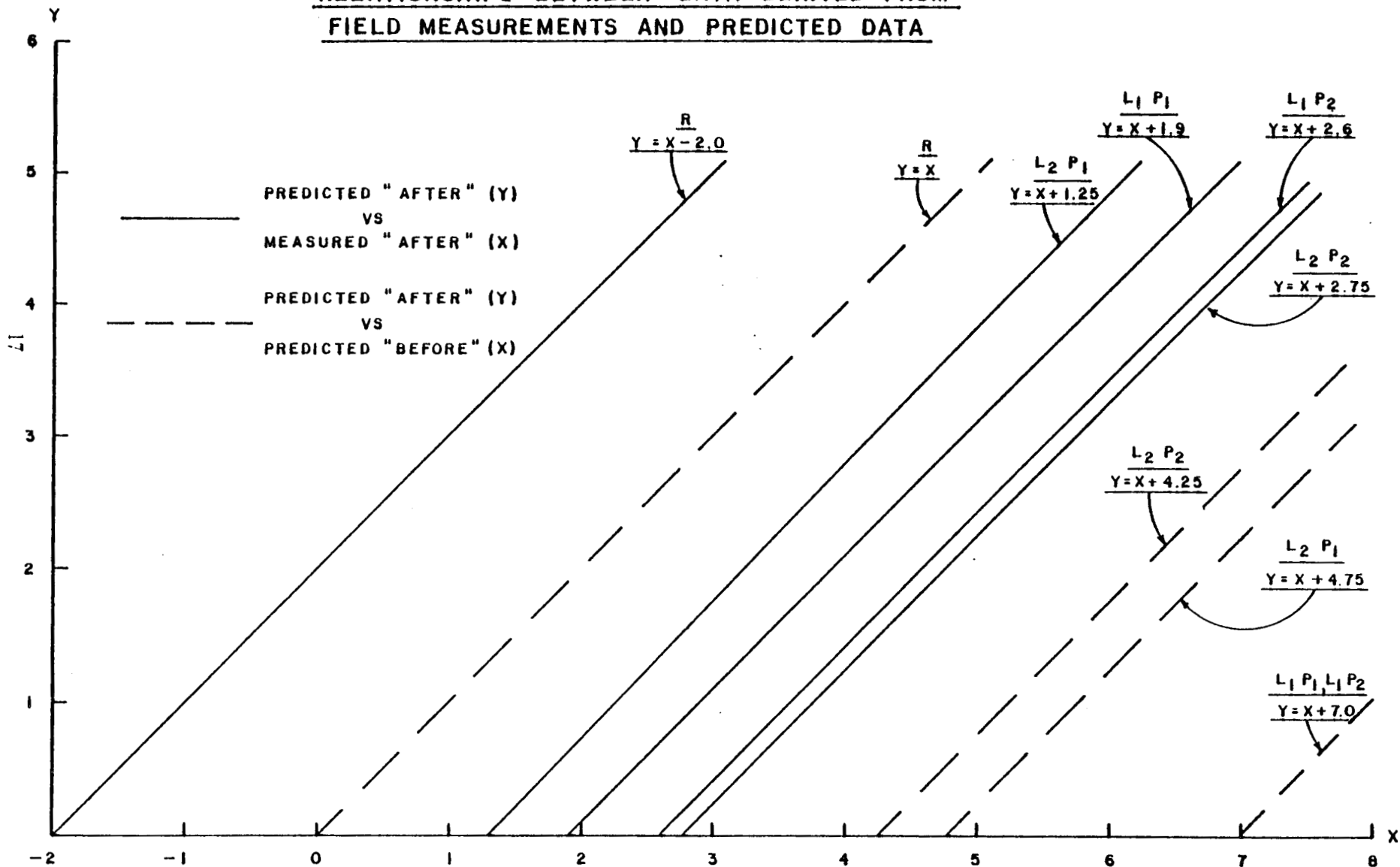
MICROPHONE POSITION	SAMPLE SIZE		
	FROM FIELD MEASUREMENTS	PREDICTED "BEFORE"	PREDICTED "AFTER"
R	49	66	66
L1P1	41	66	66
L1P2	41	66	66
L2P1	52	66	66
L2P2	42	66	66

TABLE II
RELATIONSHIPS BETWEEN DATA DERIVED FROM FIELD MEASUREMENTS AND PREDICTED DATA

MICROPHONE POSITION	PREDICTED "AFTER" (Y) VS "MEASURED AFTER"* (X)	PREDICTED "AFTER" (Y) VS PREDICTED "BEFORE" (X)
R	$Y = X - 2.0$	$Y = X$
L1P1	$Y = X + 1.9$	$Y = X + 7.0$
L1P2	$Y = X + 2.6$	$Y = X + 7.0$
L2P1	$Y = X + 1.25$	$Y = X + 4.75$
L2P2	$Y = X + 2.75$	$Y = X + 4.25$

*The levels for Position R were read as Leq's directly from a sound level meter during data collection. For the other positions the noise was taperecorded and the Leq's obtained in the laboratory from the data reduction process.

FIGURE 4
RELATIONSHIPS BETWEEN DATA DERIVED FROM
FIELD MEASUREMENTS AND PREDICTED DATA



RESULTS AND DISCUSSION

The insertion losses for all microphone positions as determined by the data analysis are shown in Table III, page 19.

For both field microphone locations the insertion losses at the five-foot microphones were greater than at the ten-foot microphones. This may be due in part to ground attenuation. Most of the site was covered with grass about four inches high, with the exception of Masters Street, a local road running parallel to the highway. There were also small trees and shrubs on the slope of the roadway embankment.

The original noise impact study for this highway indicated a 15 dB insertion loss for a 12-foot barrier, and cited this height as being necessary to effectively screen truck noise.⁽²⁾ Subsequent to this report, NJDOT policy has been to design barriers for a minimum of 10 dB insertion loss. While this particular barrier clearly acts to reduce traffic noise from the highway, the results are disappointing, especially in view of the elevation of the roadway. (See Figure 2, page 11.) This is probably because of the barrier being too low. The exhaust stacks of many of the large trucks could easily be seen from the field microphone locations for a considerable distance, as the trucks proceeded along the highway.

Concerning data analysis, the techniques used are completely suitable for application in similar circumstances on other projects. The determination of the highest degree function to describe the relationships between data sets by difference table is not absolutely necessary. A quadratic (or a cubic) function could have been assumed and the regression done the same way. However, it is certainly more informative to know beforehand what to expect from the regression, and it also serves as a check on the regression results.

⁽²⁾ See Reference (4), pages 9 and 11.

TABLE III

INSERTION LOSSES WITH 95% CONFIDENCE LIMITS

MICROPHONE POSITION AND HEIGHT	DISTANCE FROM REFERENCE MICROPHONE	INSERTION LOSSES WITH CONFIDENCE LIMITS
L1P1 - 5'	150'	7.2 \pm 0.4 dB
L1P2 - 10'	150'	6.5 \pm 0.4 dB
L2P1 - 5'	300'	4.8 \pm 0.4 dB
L2P2 - 10'	300'	4.3 \pm 0.4 dB

In any instance where either the "before" or the "after" data has to be predicted, comparisons must be made with the levels derived from field measurements. First, it is very helpful to know what the relationship is between the two sets of data (e.g., predicted "after" vs. "measured after") for each microphone position, and whether or not it is the same for each. If (in the case of this study) four of the relationships had been linear and the fifth curvilinear, one would have been justified in examining all aspects of the data derivation and handling for error. If however, all five relationships had been the same whether linear or not, one would be equally justified in assuming that all results were correct simply because there is a very high probability that all operations were performed correctly five times in succession, as opposed to the very low probability that they were all performed incorrectly.

Second, the relationships can be used to determine any correction factors if needed. In this instance all ten relationships were linear with a slope of one, which eliminated the need for any correction factor(s). Had any or all of the predicted "after" vs. the "measured after" relationships had a different form from the corresponding predicted "after" vs. predicted "before" relationships, correction factors might have been needed, depending upon how divergent (or convergent) the graphs of the functions were.

The fact that STAMINA 2.0 predicted accurately for the "after" case for each of the five microphone positions is an indication of the validity of the model. However, even if it had predicted levels vastly different from those measured it could have been used to determine insertion loss, provided that the slopes of the lines for the corresponding pairs of data sets was one, or if a correction factor could have been determined for non-parallel lines. In other words, the fact that the predicted levels might be 5, 10 or 15 dB higher than those derived from field measurements would not affect the difference between any pair of predicted "before" and predicted "after" levels. It is these differences which are used to determine the insertion losses, rather than the absolute values of the predicted levels.

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APPENDIX I
DATA COLLECTION PROCEDURE

Figures 2 and 3 on pages 11 and 12 show the equipment layout used for data collection. A three-man crew was necessary for this part of the project. The procedure was as follows:

1. The instrumentation van was positioned so that only one 100-foot cable was needed to reach any field microphone. A 25-foot cable was used for the Reference microphone.
2. The tripods, cables, microphones, and mast for the microphones at Location 1 and Location 2 were positioned and connected;
3. Simultaneously the tape recorders, voice microphones, timers, sound level meters, and ancillary items were set up in the instrumentation van;
4. A preliminary announcement consisting of the tape number, date, location, site, name, "after" barrier construction and signal weighting was recorded on each tape;
5. Pistonphone calibration signal was recorded for each channel in use, followed by an announcement for the start of Observation 1;
6. The traffic vehicle was positioned on the I-676 northbound shoulder and the radar set up and calibrated. The Reference microphone was also set up and calibrated. This microphone was connected to the 2218 SLM in the vehicle; the L_{eq} was read directly from this meter;
7. Initial wind speed and temperature readings were obtained at the equipment van and recorded;
8. The equipment operator was informed of the readiness of the traffic data crew;
9. The equipment operator gave the starting signal to the traffic data crew via walkie-talkie and then started the tape recorders and the timer. The traffic crew counted three classes of vehicles: light vehicles, medium trucks, and

heavy trucks, for both the northbound and southbound roadways. At least ten random radar speed readings were recorded for nearside traffic during each observation. Observations were nominally six minutes minimum but often they were longer to allow for portions containing extraneous noise (planes, trains, etc.) to be edited out during data reduction. Observations at the Reference position were exactly four minutes long;

10. The equipment operator entered pertinent information such as meter settings, starting time and duration of each observation, etc. on forms provided for this purpose. He also noted any unusual noise such as that from planes or trains which might have to be edited out when the observation was reduced to obtain an L_{eq} for traffic noise only;
11. At the end of the observation the operator stopped the recorders and the timer and signalled the traffic data crew to stop. He then recorded the end of the observation and the start of the next one on the tape.
12. Upon being given the ready signal from the traffic data crew, the operator signalled the start of the next observation, repeating the applicable preceding steps.

Because of equipment limitations, it was possible to record data from no more than four microphones simultaneously. For this reason the L_{eq} at the Reference position was read directly from the 2218 SLM. Observations from this position containing non-traffic noise were noted and discarded during the editing process.

APPENDIX I

MAJOR ITEMS OF DATA COLLECTION EQUIPMENT

- 1 - 2204 B & K Sound Level Meter
- 1 - 2209 B & K Sound Level Meter
- 1 - 2218 B & K Integrating Sound Level Meter
- 4 - B & K 1-inch microphones with preamps, input stages, random incidence correctors, windscreens, dessicators
- 1 - B & K 1/2-inch microphone with input stage (used with 2218 SLM)
- 1 - K-55 MPH Radar Speed Detector
- 2 - IV-SJ Nagra Tape Recorders
- 1 - Set headphones
- 3 - Walkie-talkies
- 1 - Stop watch
- 1 - Microphone mast and base for Reference microphone
- 4 - Tripods for field microphones

APPENDIX II
DATA REDUCTION PROCEDURE

Data reduction was accomplished by one man. Editing of tapes was done by the same person throughout the entire data reduction process in order to ensure uniformity of results. Types of extraneous noise edited from the tapes included that from aircraft, trains, municipal equipment and vehicles, private and commercial vehicles, pedestrians, and general neighborhood noises. The routine was as follows:

1. The data reduction equipment was set up as shown in Figure 5, page 27;
2. All controls were set for proper readings, levels, speeds, etc.;
3. The tape was started on playback and the Graphic Level Recorder pen set at the appropriate level to record the calibration signal. The 2218 B & K SLM was checked for the correct L_{eq} . The calibration signal was checked for uniform level;
4. The voice announcement following calibration signal was checked for necessary information (tape number, date, observation number, etc.) and to ascertain that it agreed with field notes. This information was written on the graph at the start of the first observation;
5. The graph of the first observation on the channel was recorded. By consulting the field notes and listening to the monitor speaker it was possible to determine where extraneous noises occurred during the observation. The type of noise and the start and stop of each occurrence were marked on the graph;
6. At the end of the observation the voice announcement was checked, the start of the next observation indicated on the graph, and reduction proceeded as before;
7. At the end of the last observation the tape was checked for final voice announcement and calibration signal. The tape was then rewound to the start of the first observation;

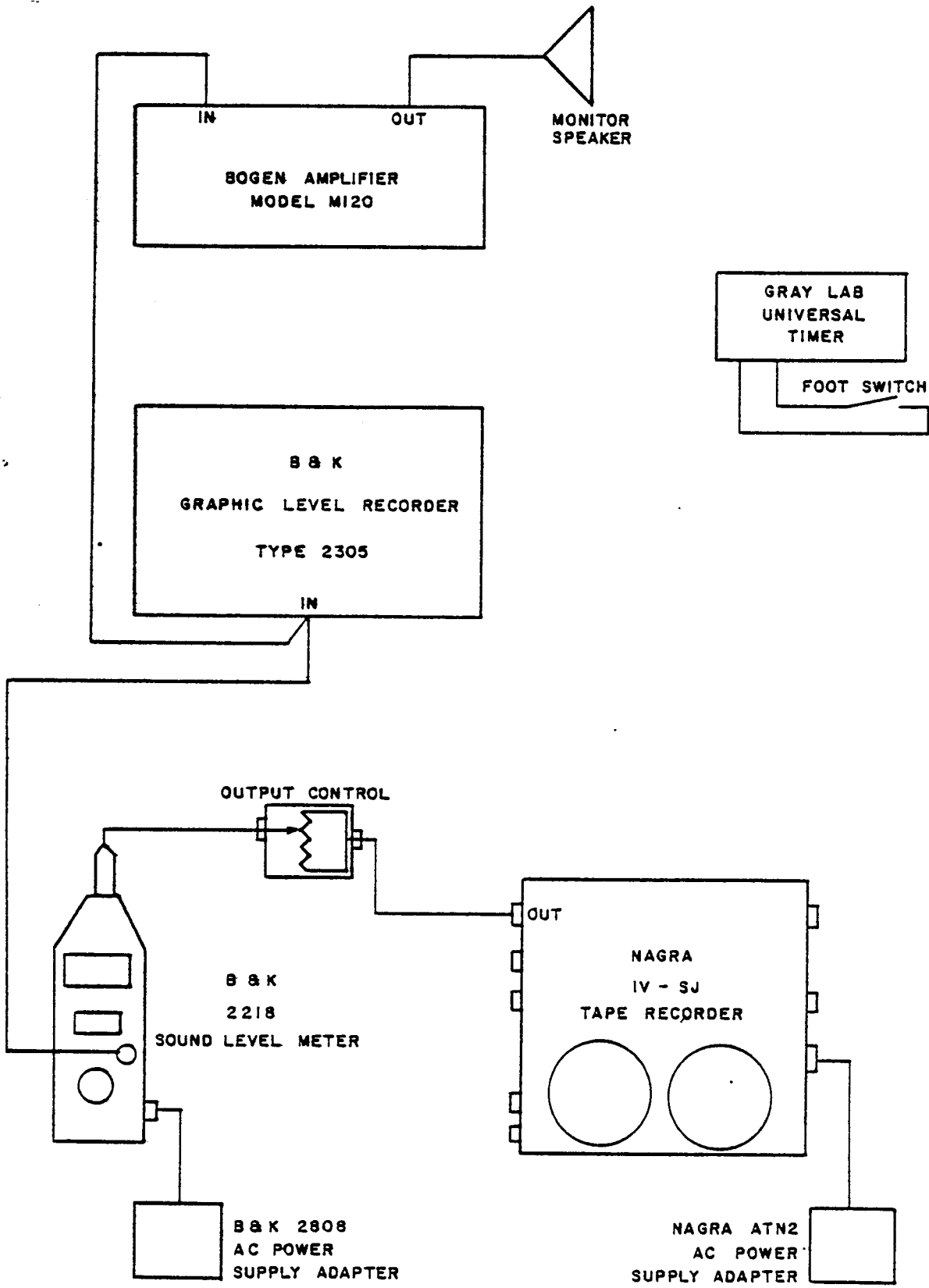
8. The tape was rerun on the same channel, using the graph and a timer to obtain an L_{eq} for 4m of traffic noise for each observation, where available. Observations not meeting this requirement were discarded;

9. At the end of the last observation the tape was rewound and Steps 3 - 10 were repeated for the second channel;

The speed of the near side traffic was determined by averaging the radar readings taken during the observation. A minimum of 10 readings were taken each time. All traffic counts were prorated from the actual count obtained during the observation. For instance, a light vehicle count of 198 for a six-minute observation was prorated by taking $\frac{4m}{6m} \times 198 = 132$.

Prorated counts were reported to the nearest tenth.

FIGURE 5
DATA REDUCTION EQUIPMENT LAYOUT



APPENDIX II

MAJOR ITEMS OF DATA REDUCTION EQUIPMENT

- 1 - B & K 2305 Graphic Level Recorder
- 1 - B & K 2218 Integrating Sound Level Meter
- 1 - Nagra Tape Recorder Type IV - SJ
- 1 - M120 Bogen Audio Amplifier
- 1 - Misco Monitor Speaker
- 1 - Gray Lab Universal Timer

EXPLANATION OF COLUMN HEADINGS
FOR APPENDICES III-V

- OBS - Total number of usable observations to this point.
- DATE - Date observation was recorded.
- OBSNO - Sequential observation number for the particular date.
- REF - L_{eq} for the particular observation from the Reference microphone.
- LxPy - L_{eq} for the particular observation from the microphone at Location x,
Position y.
- *SPD - The average speed of nearside traffic for the particular observation,
determined from at least ten radar readings.
- *NSL - The number of light vehicles travelling in the nearside lanes during the
observation, prorated to 4m from the original count. The prorated count is
reported to the nearest tenth.
- *NSM - Same as above for nearside medium trucks.
- *NSH - Same as above for nearside heavy trucks.
- *FSL - Same as NSL for farside traffic.
- *FSM - Same as NSM for farside traffic.
- *FSH - Same as NSH for farside traffic.
- *Not used in Appendices IV and V.

APPENDIX III
I-676 FIELD DATA
AFTER BARRIER CONSTRUCTION

OBS	DATE	OBSNO	REF	L1P1	L1P2	L2P1	L2P2	SPD	NSL	NSM	NSH	FSL	FSM	FSH
1	10/12/82	1	.	54.6	55.7	54.9	54.1	53.1	64.0	6.9	2.3	48.0	2.3	3.4
2	10/12/82	2	77.9	55.8	56.3	55.8	55.4	54.2	46.7	2.7	4.0	51.3	3.3	2.0
3	10/12/82	3	80.7	57.1	58.0	57.1	56.6	53.8	42.0	2.7	2.0	49.3	2.0	3.3
4	10/12/82	4	76.4	53.5	56.9	.	53.8	54.2	66.0	2.7	7.3	46.7	4.0	2.0
5	10/12/82	5	78.7	54.5	55.0	55.4	54.1	53.9	44.0	2.0	0.7	38.0	.	3.3
6	10/12/82	6	77.7	.	.	54.8	54.2	55.3	49.3	1.3	4.5	40.2	1.3	3.9
7	10/12/82	7	78.3	.	.	56.5	55.8	53.5	54.6	1.9	2.6	49.3	0.7	3.3
8	10/19/82	1	77.2	.	57.3	.	.	51.9	57.3	5.3	2.7	42.7	1.3	6.0
9	10/19/82	2	77.1	.	55.9	.	.	53.6	61.0	1.9	1.3	60.3	3.2	3.2
10	10/19/82	3	78.3	.	57.6	.	.	55.2	48.0	3.9	3.9	46.0	1.3	3.9
11	10/19/82	4	78.1	.	58.9	.	.	53.7	54.3	0.6	3.4	44.0	2.9	1.7
12	10/19/82	5	78.0	.	57.2	.	.	53.0	54.8	1.8	1.8	60.3	3.7	1.8
13	10/19/82	6	76.4	.	56.7	.	.	53.4	57.8	3.1	3.7	49.2	1.8	3.1
14	10/19/82	7	.	.	58.6	.	.	54.3	44.0	2.0	2.7	53.3	1.3	4.0
15	10/19/82	8	79.1	55.6	.	.	.	53.0	67.5	2.6	2.6	61.0	1.9	5.8
16	10/19/82	9	78.3	57.0	57.5	.	.	52.5	74.6	2.6	2.6	81.1	1.3	2.6
17	10/19/82	10	.	55.1	56.1	.	.	53.3	72.7	4.7	4.7	98.0	3.3	4.0
18	10/27/82	1	78.7	54.6	56.1	55.0	54.9	54.1	61.0	0.6	3.9	41.5	0.6	3.2
19	10/27/82	2	78.1	54.1	56.0	55.0	54.0	53.6	48.7	2.0	4.7	52.0	2.0	2.7
20	10/27/82	3	79.3	55.2	56.9	56.7	55.2	53.4	45.3	3.3	4.7	64.0	2.0	3.3
21	10/27/82	4	77.5	53.2	55.5	54.5	53.3	54.8	47.3	5.3	2.0	50.7	1.3	2.7
22	10/27/82	5	79.1	54.5	56.3	56.4	.	53.5	58.7	5.3	2.7	72.7	2.7	3.3
23	10/27/82	6	77.8	53.0	54.3	53.8	.	52.8	59.3	2.0	2.7	55.3	4.7	1.3
24	10/27/82	7	77.7	53.3	54.9	.	.	54.8	50.7	2.7	2.0	64.7	3.3	3.3
25	11/16/82	1	78.0	.	55.4	55.0	.	54.4	55.8	1.9	4.5	49.9	1.9	1.9
26	11/16/82	2	77.4	.	.	54.8	.	54.2	58.3	0.5	2.4	46.2	2.4	3.6
27	11/16/82	3	77.3	.	54.4	54.0	.	55.9	54.8	1.8	3.1	57.8	1.8	5.5
28	11/16/82	4	.	.	56.0	56.7	.	54.5	60.3	3.7	3.7	58.5	3.1	4.9
29	11/16/82	5	77.7	.	55.0	55.0	.	56.3	57.6	4.5	1.3	50.3	3.2	5.8
30	11/16/82	6	78.3	.	54.8	55.7	.	54.5	61.4	3.2	1.9	62.1	5.1	5.1
31	11/16/82	7	77.8	.	.	53.9	.	55.1	53.8	4.5	2.6	60.2	2.6	3.8
32	11/17/82	1	.	57.0	.	58.3	56.6	55.1	53.3	2.7	2.0	42.0	2.0	4.7
33	11/17/82	2	78.6	55.1	57.6	56.4	55.2	55.4	61.0	5.3	1.8	52.7	1.8	5.9
34	11/17/82	3	79.4	56.0	56.8	56.3	54.5	52.8	56.8	5.0	3.3	65.7	4.4	2.8
35	11/17/82	4	78.4	56.0	.	56.2	54.3	54.7	50.7	4.0	4.7	48.0	0.7	3.3
36	11/17/82	5	80.9	58.2	60.0	58.6	57.2	52.8	64.0	6.3	6.3	41.1	1.1	4.0
37	11/17/82	6	79.0	56.1	57.4	57.1	55.9	55.3	57.3	4.7	2.7	43.3	2.7	2.0
38	11/17/82	7	78.0	56.4	57.5	57.3	.	56.1	56.0	5.3	2.7	63.3	2.7	2.7
39	12/08/82	1	78.3	57.0	55.2	56.5	55.0	59.1	48.0	3.7	1.2	55.4	3.1	4.9
40	12/08/82	2	77.7	.	.	.	.	50.4	54.7	4.0	4.0	44.0	2.7	5.3
41	12/08/82	3	79.2	56.5	54.1	54.8	53.3	58.1	48.0	2.7	4.7	47.3	2.7	3.3
42	12/08/82	4	78.8	55.8	53.6	54.0	52.5	55.3	55.0	4.5	5.1	65.3	1.3	3.8
43	12/08/82	5	.	56.5	.	54.6	53.2	56.9	48.7	3.3	3.3	69.3	5.3	3.3
44	12/08/82	6	78.1	55.7	53.5	54.8	52.9	56.8	55.3	4.7	2.0	52.0	2.7	2.7
45	12/08/82	7	78.6	57.7	55.4	57.0	55.7	54.0	58.7	2.7	3.3	54.0	4.0	4.0
46	09/27/83	1	.	57.5	55.8	56.4	56.5	55.0	57.3	4.0	6.0	55.3	2.7	6.7
47	09/27/83	2	.	59.8	57.9	56.9	56.5	55.8	58.0	2.7	3.0	52.7	4.0	3.3
48	09/27/83	3	.	57.1	53.7	54.1	54.5	52.7	46.0	3.3	4.7	80.0	3.3	7.3
49	09/27/83	4	.	58.7	.	56.4	56.8	55.0	63.3	2.7	4.7	100.0	3.3	6.0

APPENDIX III
I-676 FIELD DATA
AFTER BARRIER CONSTRUCTION

OBS	DATE	OBSNO	REF	L1P1	L1P2	L2P1	L2P2	SPD	NSL	NSM	NSH	FSL	FSM	FSH
50	09/27/83	5	.	58.8	56.3	56.5	56.3	53.7	84.7	2.0	3.3	97.3	2.0	7.3
51	09/27/83	6	.	58.0	56.1	57.1	56.6	52.5	74.7	4.0	4.0	86.7	4.7	2.7
52	09/27/83	7	.	57.3	.	56.1	56.1	53.8	52.7	0.7	2.7	102.0	4.0	4.0
53	10/31/83	1	78.2	57.3	.	56.4	56.2	52.2	50.5	2.5	3.7	78.2	2.5	3.1
54	10/31/83	2	79.1	57.2	.	57.5	56.9	55.2	56.7	3.3	6.7	75.3	4.0	3.3
55	10/31/83	3	80.3	.	.	58.7	57.7	54.4	56.3	3.2	10.9	65.9	3.2	6.4
56	10/31/83	4	80.3	.	.	57.6	56.9	53.4	74.0	6.7	7.3	72.0	2.7	4.7
57	10/31/83	5	79.1	.	.	56.3	55.3	53.8	76.7	1.3	2.7	78.7	0.7	3.3
58	10/31/83	6	.	.	.	58.5	59.3	53.7	62.0	4.0	4.0	73.3	4.7	6.7
59	10/31/83	7	79.9	.	.	58.6	57.6	55.0	61.3	4.7	4.7	80.7	4.7	2.7
60	11/01/83	1	79.6	58.6	.	57.8	56.7	54.4	58.7	2.7	6.0	66.0	8.0	8.0
61	11/01/83	2	.	.	.	.	.	54.1	67.3	0.7	6.7	70.0	3.3	2.7
62	11/01/83	3	.	.	.	56.8	.	54.1	61.4	1.3	2.6	83.2	1.9	5.8
63	11/01/83	4	79.7	58.2	.	56.3	54.5	55.2	63.4	6.4	7.7	72.3	3.8	3.8
64	11/01/83	5	80.3	56.2	.	55.6	54.9	54.8	80.7	7.3	4.0	94.0	4.7	4.0
65	11/01/83	6	.	58.0	.	56.7	56.1	53.8	86.3	1.3	3.2	83.0	4.5	6.5
66	11/01/83	7	80.2	.	.	55.5	54.2	55.0	54.8	3.1	4.9	83.7	2.5	4.9

APPENDIX IV
I-676 PREDICTED DATA
BEFORE BARRIER CONSTRUCTION

OBS	DATE	OBSNO	REF	L1P1	L1P2	L2P1	L2P2
1	10/12/82	1	76.4	65.0	65.4	61.6	61.8
2	10/12/82	2	76.2	64.8	65.1	61.3	61.4
3	10/12/82	3	75.1	63.7	64.1	60.6	60.7
4	10/12/82	4	77.9	66.6	66.8	62.8	62.9
5	10/12/82	5	73.6	62.1	62.5	59.2	59.3
6	10/12/82	6	76.5	65.3	65.6	61.8	61.9
7	10/12/82	7	75.2	63.8	64.2	60.6	60.7
8	10/19/82	1	76.4	65.2	65.5	61.9	62.0
9	10/19/82	2	75.0	63.3	63.8	60.5	60.7
10	10/19/82	3	76.7	65.5	65.3	62.0	62.1
11	10/19/82	4	75.4	63.8	64.2	60.5	60.6
12	10/19/82	5	74.7	63.0	63.4	60.0	60.2
13	10/19/82	6	75.2	64.9	65.2	61.4	61.5
14	10/19/82	7	75.7	64.4	64.7	61.2	61.3
15	10/19/82	8	76.3	65.0	65.3	61.9	62.0
16	10/19/82	9	75.9	64.2	64.6	61.0	61.2
17	10/19/82	10	77.0	66.2	66.5	62.1	62.0
18	10/27/82	1	75.9	64.5	64.8	61.1	61.2
19	10/27/82	2	76.5	65.2	65.5	61.6	61.7
20	10/27/82	3	76.7	65.5	65.7	61.9	62.0
21	10/27/82	4	75.8	64.4	64.8	61.0	61.2
22	10/27/82	5	76.6	65.2	65.5	61.9	62.0
23	10/27/82	6	75.4	63.7	64.1	60.5	60.7
24	10/27/82	7	75.7	64.2	64.6	61.2	61.3
25	11/16/82	1	76.3	64.9	65.2	61.3	61.4
26	11/16/82	2	75.2	63.7	64.1	60.7	60.8
27	11/16/82	3	76.5	65.3	65.6	62.2	62.3
28	11/16/82	4	77.1	65.9	66.2	62.6	62.7
29	11/16/82	5	76.4	65.1	65.5	62.1	62.3
30	11/16/82	6	76.4	65.0	65.4	62.1	62.2
31	11/16/82	7	76.4	65.1	65.4	61.8	61.9
32	11/17/82	1	75.7	64.4	64.8	61.3	61.4
33	11/17/82	2	76.6	65.3	65.7	62.2	62.3
34	11/17/82	3	76.6	65.2	65.5	61.8	62.0
35	11/17/82	4	77.0	65.8	66.0	62.1	62.2
36	11/17/82	5	77.9	66.7	67.0	63.0	63.0
37	11/17/82	6	76.2	64.7	65.0	61.3	61.4
38	11/17/82	7	76.7	65.3	65.6	61.9	62.0
39	12/09/82	1	75.3	64.7	65.3	62.0	62.1
40	12/08/82	2	76.4	65.2	65.5	61.8	61.9
41	12/08/82	3	77.3	66.1	66.3	62.5	62.6
42	12/08/82	4	77.5	66.3	66.5	62.7	62.8
43	12/08/82	5	77.0	65.6	66.0	62.4	62.5
44	12/08/82	6	76.3	64.8	65.2	61.5	61.7
45	12/08/82	7	76.4	65.1	65.4	61.8	61.9
46	09/27/82	1	78.2	67.1	67.4	63.6	63.7
47	09/27/82	2	78.5	67.3	67.5	63.8	63.7
48	09/27/82	3	77.4	66.4	66.7	63.1	63.2
49	09/27/82	4	77.3	66.5	66.8	63.3	63.4

APPENDIX IV
I-676 PREDICTED DATA
BEFORE BARRIER CONSTRUCTION

OBS	DATE	OBSNO	REF	L1P1	L1P2	L2P1	L2P2
50	09/27/82	5	77.4	66.0	66.4	63.0	63.1
51	09/27/82	6	77.1	65.6	65.9	62.3	62.4
52	09/27/82	7	75.9	64.5	64.9	61.6	61.8
53	10/31/82	1	76.0	64.7	65.0	61.4	61.5
54	10/31/82	2	78.1	66.8	67.1	63.2	63.3
55	10/31/82	3	79.4	68.3	68.5	64.6	64.7
56	10/31/82	4	78.6	67.4	67.7	63.8	63.9
57	10/31/82	5	76.0	64.3	64.7	61.2	61.4
58	10/31/82	6	77.5	66.4	66.7	63.2	63.3
59	10/31/82	7	77.6	66.2	66.5	62.3	62.9
60	11/01/82	1	78.3	67.2	67.6	64.0	64.1
61	11/01/82	2	77.5	66.2	66.5	62.0	62.7
62	11/01/82	3	76.2	64.9	65.3	61.9	62.1
63	11/01/82	4	78.9	67.7	67.9	64.0	64.1
64	11/01/82	5	78.2	66.7	67.1	63.4	63.5
65	11/01/82	6	77.1	65.7	66.1	62.3	62.9
66	11/01/82	7	77.5	66.3	66.6	62.7	63.0

APPENDIX V
I-676 PREDICTED DATA
AFTER BARRIER CONSTRUCTION

OBS	DATE	OBSNC	REF	L1P1	L1P2	L2P1	L2P2
1	10/12/82	1	76.4	57.3	58.3	56.3	56.9
2	10/12/82	2	76.2	57.6	58.6	56.6	57.1
3	10/12/82	3	75.1	56.5	57.5	55.7	56.3
4	10/12/82	4	77.9	59.4	60.4	58.3	58.9
5	10/12/82	5	73.6	54.8	55.9	54.1	54.8
6	10/12/82	6	76.5	58.3	59.4	57.5	58.1
7	10/12/82	7	75.2	56.7	57.7	55.8	56.5
8	10/19/82	1	76.4	57.9	59.0	57.2	57.9
9	10/19/82	2	75.0	56.1	57.2	55.3	56.0
10	10/19/82	3	76.7	58.2	59.2	57.3	57.9
11	10/19/82	4	75.4	56.8	57.8	55.8	56.4
12	10/19/82	5	74.7	55.7	56.7	54.7	55.4
13	10/19/82	6	76.2	57.6	58.6	56.7	57.3
14	10/19/82	7	75.7	57.3	58.4	56.5	57.2
15	10/19/82	8	76.3	57.9	58.9	57.2	57.3
16	10/19/82	9	75.9	56.9	57.9	55.9	56.5
17	10/19/82	10	77.6	59.0	59.9	58.0	58.6
18	10/27/82	1	75.9	57.6	58.6	56.6	57.2
19	10/27/82	2	76.5	58.1	59.1	57.1	57.7
20	10/27/82	3	76.7	58.3	59.3	57.3	57.9
21	10/27/82	4	75.8	56.7	57.7	55.7	56.3
22	10/27/82	5	76.6	57.7	58.7	56.7	57.3
23	10/27/82	6	75.4	56.5	57.5	55.4	56.0
24	10/27/82	7	75.7	57.0	58.0	56.1	56.8
25	11/16/82	1	76.3	57.8	58.8	56.7	57.3
26	11/16/82	2	75.2	56.8	57.8	56.0	56.7
27	11/16/82	3	76.6	58.3	59.4	57.6	58.3
28	11/16/82	4	77.1	58.7	59.7	57.8	58.4
29	11/16/82	5	76.4	57.7	58.9	57.0	57.7
30	11/16/82	6	76.4	57.8	58.9	57.1	57.8
31	11/16/82	7	75.4	57.7	58.7	56.8	57.4
32	11/17/82	1	75.7	57.2	58.3	56.5	57.2
33	11/17/82	2	76.6	57.9	58.9	57.2	57.3
34	11/17/82	3	76.6	57.8	58.7	56.7	57.3
35	11/17/82	4	77.0	58.5	59.5	57.5	58.1
36	11/17/82	5	77.9	59.4	60.3	58.3	58.9
37	11/17/82	6	76.2	57.1	58.0	56.0	56.5
38	11/17/82	7	76.7	57.7	58.7	56.6	57.2
39	12/08/82	1	76.3	57.6	58.6	56.9	57.6
40	12/08/82	2	76.4	58.1	59.1	57.3	57.9
41	12/08/82	3	77.3	58.9	59.9	57.9	58.5
42	12/08/82	4	77.5	59.0	60.0	58.0	58.6
43	12/08/82	5	77.0	58.4	59.4	57.5	58.1
44	12/08/82	6	76.3	57.2	58.2	56.1	56.8
45	12/08/82	7	76.4	57.9	58.9	57.1	57.7
46	09/27/83	1	78.2	60.0	61.0	59.2	59.8
47	09/27/83	2	78.5	60.2	61.2	59.2	59.7
48	09/27/83	3	77.4	59.4	60.5	58.7	59.3
49	09/27/83	4	77.8	59.5	60.5	58.7	59.3

APPENDIX V
I-676 PREDICTED DATA
AFTER BARRIER CONSTRUCTION

OBS	DATE	OBSNO	REF	L1P1	L1P2	L2P1	L2P2
50	09/27/83	5	77.4	59.0	60.1	58.4	59.0
51	09/27/83	6	77.1	58.3	59.2	57.2	57.8
52	09/27/83	7	75.9	57.7	58.7	56.9	57.5
53	10/31/83	1	76.0	57.6	58.6	56.7	57.3
54	10/31/83	2	78.1	59.7	60.7	58.7	59.3
55	10/31/83	3	79.4	61.4	62.4	60.5	61.0
56	10/31/83	4	78.6	60.1	61.1	59.1	59.7
57	10/31/83	5	76.0	57.2	58.3	56.3	56.9
58	10/31/83	6	77.5	59.3	60.3	58.5	59.2
59	10/31/83	7	77.6	58.9	59.9	57.8	58.4
60	11/01/83	1	78.3	60.3	61.4	59.6	60.2
61	11/01/83	2	77.5	59.3	60.2	58.2	58.8
62	11/01/83	3	76.2	58.0	59.1	57.3	58.0
63	11/01/83	4	78.9	60.4	61.3	59.3	59.9
64	11/01/83	5	78.2	59.2	60.2	58.2	58.8
65	11/01/83	6	77.1	58.8	59.9	58.1	58.8
66	11/01/83	7	77.5	59.2	60.3	58.4	59.0

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