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January 2, 1980

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MEMORANDUM TO: G. F. Kemper
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SUBJECT: "Evaluation of the FHWA Highway Traffic Noise Prediction Procedure (SNAP 1)," Research Report 534; KYP-72-24; HPR-PL-1(15), Part III B

Traffic noise prediction procedures are used in the design of new highways to limit noise to specific levels. The requirement that all highways be within noise level limits has been in effect since July 1, 1972. The prediction procedure originally used in Kentucky was developed in the NCHRP Report 117. An evaluation of this procedure conducted by the Division of Research in 1973 revealed significant discrepancies between measured and predicted values and resulted in the development of a correction nomograph. This correction nomograph was incorporated into Kentucky's prediction procedure in October 1974. The Federal Highway Administration recently developed a new traffic noise prediction procedure (SNAP 1). This new procedure is to replace existing procedures beginning January 1, 1980. The objective here was to evaluate the accuracy of this new prediction procedure.

Comparisons of measured and predicted noise levels showed that predictions obtained from SNAP 1 yielded better results than the procedure currently in use. Therefore, it was recommended that this new procedure be adopted. While there was no need for any general correction factor, adjustments to specific portions of the procedure may be necessary now to optimize the predictions.

A memo containing a summary of this report along with the recommendations was sent to the Division of Environmental Analysis on December 17, 1979.

Respectfully submitted,

Jas. H. Havens
Director of Research

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cc's: Research Committee

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16. Abstract

Traffic noise prediction procedures are used in the design of new highways to determine if noise is limited to specific levels. A previous study evaluated the procedure outlined in NCHRP Report 117 and developed a correction factor which was incorporated into Kentucky's noise prediction procedure. This adjusted NCHRP 117 procedure has been used in Kentucky for the past several years. The Federal Highway Administration has developed a new procedure to predict traffic noise levels. The objective of this study was to evaluate the new prediction procedure, designated as SNAP 1.

Comparisons of measured and predicted noise levels showed that predictions obtained from SNAP 1 yield better results than from the adjusted NCHRP 117 procedure. Therefore, it is recommended that the SNAP 1 prediction procedure be adopted. There is no need for a general correction factor; however, adjustments to specific portions of the procedure may be necessary to optimize the predictions.

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Research Report
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EVALUATION OF THE FHWA HIGHWAY TRAFFIC NOISE PREDICTION PROCEDURE (SNAP 1)

KYP-72-24; HPR-PL-1(15), Part III B

by

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Commonwealth of Kentucky

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INTRODUCTION

Policy and Procedure Memorandum 90-2 of the Federal Highway Administration directed that, after July 1, 1972, all highways constructed must conform to specific design noise levels *(1)*. To predict future noise levels of highways, procedures have been developed. The prediction procedure originally used in Kentucky was developed in NCHRP Report 117 *(2)*. There were questions about the accuracy of this procedure and, therefore, an evaluation was conducted. The evaluation revealed significant discrepancies between measured and predicted values; a correction nomograph developed in this study was incorporated into Kentucky's procedure *(3)*. This nomograph used roadway-to-receiver distance, truck volume per hour, and car speed to determine a correction factor to be applied to values as determined by the method outlined in NCHRP 117. Approval was granted by FHWA in October 1974.

Research has continued toward the objective of developing a more accurate procedure. A new procedure was reported in NCHRP 174 *(4)*, and a traffic noise prediction model was developed by FHWA *(5)*. FHWA then developed computer programs *(6, 7)*; these were called Simplified Noise Analysis Programs (SNAP). SNAP 1 is used for relatively simple site geometry while SNAP 2 is used for more complex situations. The objective herein was to evaluate the accuracy of SNAP 1.

PROCEDURE

To evaluate SNAP 1, it was necessary to obtain noise measurements and compare them to those predicted by SNAP 1. Data were taken at sites having relatively simple geometry. Sites were selected near straight, level sections of roadway on unobstructed terrain so that the number of variables which might affect the evaluation would be minimal. All data were taken at a measurement height of 5 feet (2.2 m) over a ground cover of short grass. All data were taken in terms of dBA.

The majority of measurements were made with a precision sound level meter (Bruel and Kjaer Type 2209) and strip-chart recorder (Bruel and Kjaer Type 2306) (420 10-minute recordings). From the 10-minute recordings, noise levels at intervals slightly greater than one second were determined in the laboratory utilizing a digital data-reduction system. The output was punched onto computer cards through direct coupling with a card punch unit. By means of a computer program, the L_{10} and L_{eq} noise levels were computed. The L_{10} noise level is the level exceeded 10 percent of the time and is the level currently used in federal traffic noise standards. The term L_{eq} refers to the noise equivalent level. Additional data were taken with a noise level analyzer (Bruel and Kjaer Type 4426) (111 10-minute sets). A total of 531 10-minute data sets were used in the analysis.

Information about the traffic stream at the measurements sites is given in Table 1. Data were taken at six sites chosen so that data would be taken at locations offering a wide range in speeds, traffic volume, and truck volume.

Three predicted values were determined for each noise recording. First, the method outlined in NCHRP Report 117 was used to predict a value. Then the correction factor developed in the previous Kentucky research report *(3)* was applied to this value which yielded an adjusted NCHRP 117 value. Finally, SNAP 1 was used to predict the noise level. Comparison of the difference between the measured and predicted values showed which prediction procedure was most accurate. The comparisons among the prediction procedures were based on L_{10} noise levels because only the SNAP 1 procedure yielded an L_{eq} value. In addition, the measured L_{eq} values were compared to the SNAP 1 predicted L_{eq} values.

The average absolute difference between the measured noise level and predicted level was compared as a function of several variables. If this difference varied substantially as a given variable changed, it would mean that the variable in question had an effect on the error. For example, if the difference between the predicted and measured noise levels was much greater at short roadway-to-receiver distances, it would imply that a correction factor should be applied to data taken close to the roadway. Also, the average measured and predicted L_{10} noise levels for each variable range were determined.

RESULTS

A summary of data by test site is given in Table 2. The average speeds ranged from 36 mph (16 m/s) at Site 6 to 62 mph (28 m/s) at Site 3. The average total volume (vehicles per hour) ranged from 485 at Site 5 to 4,030 at Site 4. The total volume was divided into automobiles, medium trucks, and heavy trucks, as required by the procedure outlined in SNAP 1. Medium trucks are defined as vehicles having two axles and six tires, heavy trucks have three or more axles. There was a very large range in heavy truck volume -- 245 per hour at Site 3 to 8 at Site 5. These two vehicle types are considered the same when NCHRP 117 is used.

The average actual L_{10} noise level is given, in Table 2, by site as well as the average of the three predicted L_{10} values. The discrepancies previously reported with the NCHRP 117 procedure manifested again as overpredictions at every site. The largest differences were found at sites having low truck volumes and speeds. The maximum difference between the average predicted and measured noise levels was an overprediction of almost 10 dBA at Site 6. Again improvement in the predictions with the adjusted NCHRP 117 procedure resulted. The correction factor improved the average predicted value at each site and provided a very significant improvement at some of the sites. However, the predictions obtained from the SNAP 1 procedure provided the best results. For example, at Site 6, the NCHRP 117 procedure overpredicted the measured value by 9.5 dBA. The correction factor reduced this error in average values to 3.2 dBA, but the error in the SNAP 1 procedure was only 0.5 dBA. Considering the average of all measurements, there was a difference of 4.7 dBA between the measured and predicted L_{10} NCHRP 117 noise levels. This difference was reduced to 1.0 dBA by the correction factor applied to results from the NCHRP 117 procedure. However, the difference between the average measured and SNAP 1 predicted L_{10} noise level was only 0.1 dBA.

The average absolute difference between the measured and predicted noise levels were also determined (Table 3). These data also showed that SNAP 1 provided the best results and that the procedure in NCHRP 117 gave the worst results. The average difference for all sites was 5.0 dBA by the NCHRP 117 procedure. This difference was decreased to an average of 3.0 dBA by the correction factor. The smallest difference was 2.1 dBA when the SNAP 1 was used. The difference between measured and SNAP 1 values were very similar for the L_{10} and L_{eq} values.

The distribution of the differences between measured and predicted L_{10} values was summarized for each prediction procedure in Table 4. The problem with the NCHRP procedure was that it overpredicted in 90 percent of the cases, and the overprediction was by 5 dBA or more in almost 50 percent of the cases. There was still a tendency to overpredict with the adjusted NCHRP procedure. The overprediction was in 61 percent of the cases, but the percentage of cases with a difference of 5 dBA or more was reduced by 60 percent. SNAP 1 L_{10} predictions were equally distributed above and below the measured noise levels. There was a slight tendency for the SNAP 1 procedure to overpredict the L_{eq} levels; that is, in 56 percent of the cases. The large differences were reduced substantially using SNAP 1; that is, there was a difference of less than 3 dBA in about 75 percent of the cases.

The distribution of differences between measured and predicted L_{10} values for each of the six sites are given in the Appendix (Tables A-1 through A-A-6). The major differences between measured and SNAP 1 predicted noise levels occurred at two sites. SNAP 1 underpredicted at Site 3. Site 3 was unique in that it had a very high proportion of heavy trucks. The large differences occurred when the measured noise was particularly high (over 80 dBA). Site 2 had very low volumes, and large differences occurred when data were taken at a distance farther from the roadway and were particularly low levels of noise.

A comparison was made between measured and predicted L_{10} levels as a function of the magnitude of the measured noise level (Table 5). The largest differences between measured and SNAP 1 prediction occurred when the actual L_{10} level was either very low (less than 55 dBA) or very high (80 dBA or above). The SNAP 1 procedure overpredicted at the very low level and underpredicted at the very high level. Measured and SNAP 1 predictions were very close for levels measured between 55 and 80 dBA. The NCHRP predictions became better as the measured noise level increased and was better than SNAP 1 preditions when the measured L_{10} level was 80 dBA or above.

The SNAP 1 procedure also enables prediction of the L_{eq} level. The measured L_{eq} level was compared to the SNAP 1 value as shown in Table 6. The overall average measured and predicted L_{eq} levels were very close. When measured and predicted L_{eq} levels were compared site by site, the largest difference in average values was only 1.5 dBA.

In the previous evaluation of the NCHRP procedure, discrepancies found between predicted and measured noise levels were related to certain factors *(3)*. These factors were then used to develop the correction nomograph. Herein, comparisons of the difference between measured and predicted values have been made for the following variables:

(1) traffic volume (Table 7),
(2) automobile volume (Table 8),
(3) truck volume (Table 9),
(4) heavy truck volume (Table 10),
(5) medium truck volume (Table 11), and
(6) roadway-to-receiver distance (Table 12).

As was learned earlier *(3)*, the difference between measured and NCHRP 117 levels varied with distance and truck volume, specifically heavy truck volume: the difference was greater at close distances and low heavy truck volumes. This did not occur with the adjusted NCHRP 117 values. None of the other variables showed a definite relationship between the difference in the measured and predicted values. There did not appear to be a relationship between any of the variables and the difference between measured and SNAP 1 levels.

Also included in Tables 7 through 12 are the average measured and predicted noise for each variable. The results clearly showed that the NCHRP 117 procedure consistently overpredicted noise. This overprediction became worse at close roadway-to-receiver distances, low truck volumes, and low speeds. The error associated with the adjusted NCHRP 117 procedure was substantially lower; however, the remaining error was still consistently an overprediction. The SNAP 1 procedure did not either consistently overpredict or underpredict noise.

There was an overall difference between measured and SNAP 1 values of 2 dBA (Table 3). Differences of around 2 dBA existed for each of the variables tested; however, when average measured and SNAP 1 values were compared for each variable, there was a very close agreement. Since the average values were in agreement, much of the 2 dBA difference may be attributable to errors in data collection.

RECOMMENDATION

It is recommended that the SNAP 1 prediction procedure be adopted. There is no need for a generaal correction factor; however, adjustments to specific portions of the procedure may be necessary to optimize the results. For example, reference vehicle noise emission levels need to be determined specifically for Kentucky vehicles to replace the nationwide levels currently used in the prediction methodology. Also, adjustment factors for different textures of pavement need to be applied *(8)*. It is recommended that these adjustments be incorporated into the SNAP 1 procedure.

REFERENCES

1. Policy and Procedure Memorandum 90-2, Federal Highway Administration, April 26, 1972.

2. Gordon, C. B.; Calloway, W. J.; Kugler, B. A.; and Nelson, D. L.; *Highway Noise -- A Design Guide for Highway Engineers,* National Cooperative Highway Research Program Report No. 117, Highway Research Board, 1971.

3. Agent, K. R.; and Zegeer, C. V.; *Evaluation of the Traffic Noise Prediction Procedure,* Report 379, Division of Research, Kentucky Department of Transportation, November 1973.

4. Kugler, B. A.; Commins, D. E.; and Galloway, W. J.; *Highway Noise -- A Design Guide for Prediction and Control,* National Cooperative Highway Research Program Report 174, Transportation Research Board, 1976.

5. Barry, T. M.; and Reagon, J. A.; *FHWA Highway Traffic Noise Prediction Model,* U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-77-108, July 1978.

6. Rudder, F. F., Jr.; and Lam, D. F.; *User's Manual, FHWA Highway Traffic Noise Prediction Model SNAP 1.0,* U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-78-139, January 1979.

7. Rudder, F. F., Jr.; and Cheung, P.; *User's Manual, FHWA Level 2 Highway Traffic Noise Prediction Model,* U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-78-138, July 1978.

8. Agent, K. R.; and Zegeer, C. V.; *Effect of Pavement Texture on Traffic Noise,* Report 417, Division of Research, Kentucky Department of Transportation, February 1975.

TABLE 1. TRAFFIC NOISE MEASUREMENT SITES

SITE NUMBER	ROUTE	LOCATION (CITY)	HIGHWAY NAME	TYPE OF LOCATION	SPEED LIMIT MPH (M/S)	AVERAGE SPEED MPH (M/S)	NUMBER OF 10-MINUTE MEASUREMENTS
1	US27	LEXINGTON	SOUTH LIMESTONE STREET	URBAN	40(18)	37(17)	120
2	US68	LEXINGTON	HARRODSBURG ROAD	RURAL	55(25)	54(24)	90
3	I75	LEXINGTON	INTERSTATE 75	RURAL	55(25)	62(28)	123
4	I264	LOUISVILLE	WATTERSON EXPRESSWAY	RUBAN	55(25)	48(21)	99
5	US60	LEXINGTON	WINCHESTER ROAD	RURAL	55(25)	53(24)	58
6	US31W	LOUISVILLE	DIXIE HIGHWAY	URBAN	40(18)	36(16)	42

TABLE 2. SUMMARY OF DATA BY TEST SITE

SITE NUMBER	AVERAGE VOLUMES (VPH)					SPEED LIMIT MPH (M/S)	AVERAGE PREDICTED L10 NOISE LEVELS (DBA) PREDICTION PROCEDURE			AVERAGE MEASURED L10 NOISE LEVEL (DBA)	NUMBER OF MEASUREMENTS
	TOTAL	AUTO	MEDIUM TRUCK	HEAVY TRUCK	TOTAL TRUCK		NCHRP-117	ADJUSTED NCHRP-117	SNAP-1		
1	2110	2064	41	6	47	40 (18)	69.0	61.5	62.9	62.9	120
2	519	477	27	16	43	55 (25)	68.6	64.3	64.1	64.3	90
3	1469	1153	70	245	315	55 (25)	74.9	74.4	71.5	72.9	123
4	4030	3701	150	180	330	55 (25)	79.3	78.1	74.9	73.3	99
5	484	453	22	8	30	55 (25)	65.8	62.0	62.9	63.8	58
6	2925	2740	127	64	191	40 (18)	77.7	71.4	68.7	68.2	42
OVERALL	1937	1767	70	100	170	DNA	72.5	68.9	67.8	67.9	532

TABLE 3. AVERAGE, ABSOLURE DIFFERENCE BETWEEN MEASURED AND PREDICTED NOISE LEVELS

SITE NUMBER	AVERAGE ABSOLUTE DIFFERENCE BETWEEN MEASURED AND PREDICTED NOISE LEVELS(DBA)			
	PREDICTION PROCEDURE			
	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ
1	6.1	2.5	1.8	1.8
2	4.4	2.1	2.5	2.4
3	3.0	2.8	2.5	2.5
4	6.1	4.8	2.0	1.7
5	3.2	3.0	2.0	1.8
6	9.5	3.5	1.4	1.4
ALL SITES	5.0	3.0	2.1	2.0

TABLE 4. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP 117(610)	ADJUSTED NCHRP 117(L10)	SNAP 1 L10	SNAP 1 LEQ	NCHRP 117(L10)	ADJUSTED NCHRP 117(L10)	SNAP 1 L10	SNAP 1 LEQ
LESS THAN 1.0	18	44	65	64	23	46	65	74
1.0 - 1.9	14	40	60	57	40	64	76	72
2.0 - 2.9	8	35	62	55	46	62	63	73
3.0 - 3.9	4	28	39	34	52	50	35	40
4.0 - 4.9	4	27	21	13	64	44	13	24
5.0 OR ABOVE	4	27	14	5	255	77	10	14

* THE MEASURED AND PREDICTED L10 NOISE LEVELS WERE EQUAL IN 8 CASES FOR THE ADJUSTED NCHRP-117 AND 9 CASES FOR SNAP 1 PREDICTION PROCEDURES. THEY WERE NEVER EQUAL USING THE NCHRP-117 PROCEDURE. THE ACUTAL AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN 7 CASES USING THE SNAP 1 PROCEDURE.

TABLE 5. COMPARISON OF MEASURED AND PREDICTED L10 NOISE LEVELS AS A FUNCTION OF THE MAGNITUDE OF THE MEASURED NOISE LEVEL

MEASURED NOISE LEVEL(DBA)	NUMBER OF MEASUREMENTS	AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED (DBA) — PREDICTION PROCEDURE USED			AVERAGE L10 NOISE LEVEL (DBA)			
		NCHRP-117	ADJUSTED NCHRP-117	SNAP 1	SNAP 1	NCHRP-117	ADJUSTED NCHRP-117	MEASURED
LESS THAN 55	11	5.0	2.9	3.4	56.7	58.6	56.4	53.6
55 - 59.9	46	5.0	2.1	2.0	58.8	63.0	58.4	58.3
60 - 64.9	125	5.2	2.6	2.0	63.5	67.8	62.6	62.8
65 - 69.9	161	5.2	3.3	1.8	67.6	72.4	68.3	67.4
70 - 74.9	92	5.1	3.2	2.4	71.4	77.1	74.4	72.5
75 - 79.9	77	4.9	3.6	3.3	76.5	81.8	80.1	77.5
80 OR ABOVE	20	3.2	3.2	3.3	77.8	81.7	80.0	81.0

TABLE 6. COMPARISON OF MEASURED LEQ NOISE LEVEL WITH PREDICTED VALUE (SNAP 1)

	LEQ NOISE LEVEL (DBA)	
SITE NUMBER	MEASURED	PREDICTED
1	60.7	61.0
2	61.4	62.9
3	69.4	68.2
4	70.6	71.8
5	60.3	60.9
6	65.5	65.7
ALL	65.0	65.4

TABLE 7. COMPARISON OF MEASURED VERSUS PREDICTED NOISE LEVELS BY TOTAL VOLUME

		AVERAGE DIFFERENCE BETWEEN AVPREDICTED AND MEASURED — PREDICTION PROCEDURE USED				AVERAGE L10 NOISE LEVEL (DBA)			
TRAFFIC VOLUME	NUMBER OF MEASUREMENTS	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	MEASURED	NCHRP-117	ADJUSTED NCHRP-117	SNAP 1
LESS THAN OR EQUAL TO 500	93	3.0	2.6	2.2	2.0	63.4	65.9	61.9	62.5
501 - 1000	69	4.8	2.1	2.1	2.3	66.3	71.1	67.5	66.8
1001 - 1500	68	3.5	3.2	2.2	2.4	71.2	74.0	72.9	70.6
1501 - 2000	77	5.1	2.4	2.0	2.3	66.7	71.7	66.2	66.4
2001 - 2500	62	6.3	2.5	2.3	2.0	66.4	71.8	66.6	65.5
2501 - 3000	50	5.5	3.2	1.9	1.7	67.6	72.8	67.7	67.2
3001 - 4000	74	7.1	4.6	1.6	1.5	71.8	79.0	76.3	72.8
GREATER THAN 4000	39	6.3	4.4	2.4	2.0	72.5	78.6	76.8	74.7

TABLE 8. COMPARISON OF MEASURED VERSUS PREDICTED NOISE LEVELS BY AUTO VOLUME

AUTO VOLUME	NUMBER OF MEASUREMENTS	AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED — PREDICTION PROCEDURE USED: NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	AVERAGE L10 NOISE LEVEL (DBA): MEASURED	NCHRP-117	ADJUSTED NCHPR-117	SNAP 1	AVERAGE LEQ NOISE LEVEL (DBA): SNAP 1	ACTUAL
LESS THAN OR EQUAL TO 500	105	3.3	2.5	2.2	2.1	63.6	66.4	62.4	62.9	61.4	60.4
501 - 1000	93	4.4	2.8	2.0	2.2	67.5	71.8	69.4	68.0	65.4	64.4
1001 - 1500	62	3.1	2.7	2.6	2.7	73.5	75.7	73.8	71.6	68.4	70.2
1501 - 2000	67	6.0	2.2	2.1	2.4	65.0	70.4	64.4	64.8	62.6	62.5
2001 - 2500	62	6.4	2.7	1.8	1.6	66.5	72.4	66.8	65.8	63.4	63.8
2501 - 3000	44	5.7	3.7	1.8	1.6	68.3	74.0	69.4	68.5	66.0	65.9
3001 - 4000	62	7.3	4.6	1.6	1.5	71.7	79.0	76.1	72.6	69.5	68.8
GREATER THAN 4000	37	6.4	4.5	2.4	2.0	72.2	78.4	76.6	74.6	71.7	69.8

TABLE 9. COMPARISON OF MEASURED VERSUS PREDICTED NOISE LEVELS BY TOTAL TRUCK VOLUME *

TRUCK VOLUME	NUMBER OF MEASUREMENTS	AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED PREDICTION PROCEDURE USED: NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	AVERAGE L10 NOISE LEVEL (DBA): MEASURED	NCHRP-117	ADJUSTED NCHRP-117	SNAP 1	AVERAGE LEQ NOISE LEVEL (DBA): SNAP 1	ACTUAL
LESS THAN OR EQUAL TO 100	263	4.3	2.4	2.0	2.0	63.5	68.1	62.5	63.2	61.6	60.8
101 - 200	54	7.3	2.7	1.8	1.8	68.1	75.4	70.5	69.0	65.9	65.3
201 - 300	88	5.1	3.3	2.0	2.1	72.1	76.8	74.9	72.1	68.8	69.0
GREATER THAN 300	127	4.4	4.2	2.3	2.2	74.1	77.7	77.4	73.8	70.6	70.9

* INCLUDES MEDIUM PLUS HEAVY TRUCK VOLUMES.

TABLE 10. COMPARISON OF MEASURED VERSUS PREDICTED NOISE LEVELS BY HEAVY TRUCK VOLUME*

HEAVY TRUCK VOLUME	NUMBER OF MEASUREMENTS	AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED — PREDICTION PROCEDURE USED: NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	AVERAGE L10 NOISE LEVEL (DBA): MEASURED	NCHRP-117	ADJUSTED NCHRP-117	SNAP 1	AVERAGE LEQ NOISE LEVEL (DBA): SNAP 1	ACTUAL
LESS THAN OR EQUAL TO 100	306	5.5	2.6	2.0	1.9	64.1	69.3	63.7	64.0	62.2	61.4
101 - 200	117	5.4	3.7	1.9	1.9	72.6	77.8	76.0	73.2	70.0	69.6
201 - 300	74	3.8	3.6	2.4	2.3	73.6	76.4	76.0	72.9	69.6	70.3
GREATER THAN 300	35	2.8	3.3	2.7	2.6	73.3	74.6	75.4	72.0	68.8	69.8

* HEAVY TRUCKS GENERALLY REFER TO DIESEL-POWERED, THREE-OR-MORE AXLE TRUCK COMBINATIONS.

TABLE 11. COMPARISON OF MEASURED VERSUS PREDICTED NOISE LEVELS BY MEDIUM TRUCK VOLUME *

		AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED — PREDICTION PROCEDURE USED				AVERAGE L10 NOISE LEVELS (DBA)				AVERAGE LEQ NOISE LEVEL (DBA)	
MEDIUM TRUCK VOLUME	NUMBER OF MEASUREMENTS	NCHRP-117(L10)	NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	MEASURED	NCHRP-117	ADJUSTED NCHRP-117	SNAP 1	SNAP 1	ACTUAL
LESS THAN OR EQUAL TO 100	386	4.5	2.6	2.1	2.1	66.2	70.3	66.0	65.8	63.6	63.3
101 - 200	129	6.2	4.1	2.0	1.9	72.3	78.1	76.2	72.9	69.8	69.4
201 - 300	17	7.5	6.0	1.7	1.6	73.6	81.1	79.6	75.0	71.7	70.4

* MEDIUM TRUCKS GENERALLY REFER TO GASOLINE-POWERED, TWO-AXLE, SIX WHEEL VEHICLES.

TABLE 12. COMPARISON OF MEASURED VERSUS PREDICTED L10 NOISE LEVELS BY DISTANCE

		AVERAGE DIFFERENCE BETWEEN PREDICTED AND MEASURED — PREDICTION PROCEDURE USED				AVERAGE L10 NOISE LEVEL (DBA)				AVERAGE LEQ NOISE LEVEL (DBA)	
DISTANCE (FEET) (M)	NUMBER OF MEASUREMENTS	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	MEASURED	NCHRP-117	ADJUSTED NCHRP-117	SNAP 1	SNAP 1	MEASURED
LESS THAN OR EQUAL TO 100 (30.5)	192	5.9	3.1	1.9	2.0	70.7	76.0	71.4	70.4	68.0	67.8
101 - 200 (30.8-61.0)	146	5.0	2.7	2.1	2.0	63.4	68.2	64.6	64.3	61.8	60.7
201 - 300 (61.3-91.4)	116	5.2	3.5	2.3	2.0	67.5	69.6	70.2	66.9	64.0	64.2
GREATER THAN 300 (91.4)	78	2.7	2.7	2.2	2.3	60.0	62.1	60.8	58.9	56.7	57.6

* ROADWAY TO RECEIVER DISTANCE MEASURED FROM THE CENTERLINE OF THE NEAR TRAFFIC LANE.

APPENDIX

TABLE A-1. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 1)

	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
NOISE LEVEL DIFFERENCE RANGE (DBA)	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ
LESS THAN 1.0	0	13	19	19	2	14	18	18
1.0 - 1.9	0	17	19	18	4	11	16	15
2.0 - 2.9	0	15	12	14	8	4	17	11
3.0 - 3.9	0	10	3	4	11	7	8	10
4.0 - 4.9	0	12	3	2	17	1	1	8
5.0 OR ABOVE	1	13	2	0	77	0	0	0

* THE MEASURED AND PREDICTED L10 NOISE LEVELS WERE EQUAL IN 3 CASES FOR THE ADJUSTED NCHRP-117 PROCEDURE AND IN 2 CASES FOR THE SNAP 1 PROCEDURE. THE MEASURED AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN ONE CASE USING THE SNAP 1 PROCEDURE.

TABLE A-2. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 2)

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1		NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1	
			L10	LEQ			L10	LEQ
LESS THAN 1.0	0	10	11	7	5	11	8	11
1.0 - 1.9	2	12	12	6	9	13	13	15
2.0 - 2.9	1	10	11	5	13	11	4	13
3.0 - 3.9	0	7	5	2	9	0	6	14
4.0 - 4.9	0	1	4	1	11	8	1	6
5.0 OR ABOVE	0	3	6	1	40	2	8	8

* THE MEASURED AND PREDICTED L10 NOISE LEVELS WERE EQUAL IN TWO CASES FOR THE ADJUSTED NCHRP-117 PROCEDURE AND IN ONE CASE FOR THE SNAP 1 PROCEDURE. THE MEASURED AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN 1 CASE USING THE SNAP 2 PROCEDURE.

TABLE A-3. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 3)

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ
LESS THAN 1.0	12	10	14	12	7	11	9	10
1.0 - 1.9	5	2	10	12	18	24	11	8
2.0 - 2.9	7	5	20	19	17	14	9	12
3.0 - 3.9	2	5	23	27	17	17	3	6
4.0 - 4.9	4	3	14	10	16	9	2	0
5.0 OR ABOVE	2	5	5	4	16	15	1	2

* THE MEASURED AND PREDICTED L10 NOISE LEVELS WERE EQUAL IN 3 CASES FOR THE ADJUSTED NCHRP-117 PROCEDURE AND IN 2 CASES FOR THE SNAP 1 PROCEDURE. THE MEASURED AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN 1 CASE USING THE SNAP 1 PROCEDURE.

TABLE A-4. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 4)

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1		NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1	
			L10	LEQ			L10	LEQ
LESS THAN 1.0	0	2	5	8	1	3	16	18
1.0 - 1.9	0	1	6	7	3	7	23	20
2.0 - 2.9	0	0	5	6	4	7	25	25
3.0 - 3.9	1	0	0	0	8	17	12	7
4.0 - 4.9	0	0	0	0	14	12	7	5
5.0 OR ABOVE	0	0	0	0	68	50	0	1

* THE MEASURED AND PREDICTED LEQ NOISE LEVELS WERE EQUAL IN 2 CASES USING THE SNAP 1 PROCEDURE.

TABLE A-5. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 5)

	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
			SNAP 1				SNAP 1	
NOISE LEVEL DIFFERENCE RANGE (DBA)	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	L10	LEQ	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	L10	LEQ
LESS THAN 1.0	6	5	8	12	8	5	8	10
1.0 - 1.9	7	7	8	10	6	6	3	4
2.0 - 2.9	0	4	13	4	4	2	2	5
3.0 - 3.9	1	6	6	1	7	2	4	3
4.0 - 4.9	0	11	0	0	6	2	2	5
5.0 OR ABOVE	1	6	1	0	12	2	1	3

* USING THE SNAP 1 PROCEDURE THE MEASURED AND THE PREDICTED NOISE LEVELS WERE EQUAL IN 2 CASES FOR L10 AND IN 1 CASE FOR LEQ.

TABLE A-6. DISTRIBUTION OF DIFFERENCES BETWEEN MEASURED AND PREDICTED NOISE LEVELS (SITE 6)

NOISE LEVEL DIFFERENCE RANGE (DBA)	NUMBER OF MEASUREMENTS IN GIVEN NOISE LEVEL DIFFERENCE RANGE*							
	MEASURED GREATER THAN PREDICTED				PREDICTED GREATER THAN MEASURED			
	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ	NCHRP-117(L10)	ADJUSTED NCHRP-117(L10)	SNAP 1 L10	SNAP 1 LEQ
LESS THAN 1.0	0	4	8	6	0	2	6	7
1.0 - 1.9	0	1	5	4	0	3	10	10
2.0 - 2.9	0	1	1	7	0	4	6	7
3.0 - 3.9	0	0	2	0	0	7	2	0
4.0 - 4.9	0	0	0	0	0	12	0	0
5.0 OR ABOVE	0	0	0	0	42	8	0	0

* USING THE SNAP 1 PROCEDURE, THE MEASURED AND PREDICTED NOISE LEVELS WERE EQUAL IN 2 CASES FOR L10 AND IN ONE CASE FOR LEQ.