SIMPLIFIED TECHNIQUE FOR TRAFFIC NOISE LEVEL ESTIMATION

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MICHIGAN DEPARTMENT OF STATE HIGHWAYS

SIMPLIFIED TECHNIQUE FOR TRAFFIC NOISE LEVEL ESTIMATION

(Prepared for use in City and County situations characterized by low speed, low volume traffic operating at short distances from at-grade roadways)

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ABSTRACT

Traffic noise is becoming increasingly detrimental to the quality of our urban and rural environments. Currently, it is the predominant and most widespread source of noise. Future design and routing of highways and upgrading of our present facilities must include traffic noise as a consideration.

In our city and county areas, there exists a need for predicting noise levels at sites very near to at-grade roadways carrying low speed, low volume traffic. This report is directed to that need.

It should be noted that noise levels based on the graphs in this report are state-of-the-art predictions, as the levels graphed are outputs from the Michigan Noise Predictor Computer Program of the noise prediction method of NCHRP Report No. 117.

Future research and validation studies will undoubtedly improve the precision of prediction techniques and at that time these graphs will be updated accordingly.

The common unit for measuring noise is the decibel, abbreviated simply "db." The logarithmic decibel scale for sound level was first introduced by communication engineers many years ago. They simply took the logarithm of the amount of power change that occurred in an amplifier or attenuator and named this unit the "Bell" in honor of Alexander Graham Bell. It was soon found that this unit was far too coarse, and it became common practice to use a unit one-tenth of a Bell, called the "decibel."

In sound measurement, decibel levels are related to a reference sound pressure level of 0.0002 dyne/cm^2. This particular level represents (approximately) the faintest sound that can be heard by the ear of a healthy young adult in an extremely quiet environment.

Therefore, if any given decibel level represents the logarithm of the difference between the reference level and some sound pressure level of interest, it can be seen for example, that a decibel level of 60 refers to a sound pressure one million (10^6) times the reference level. In a like manner, a decibel level of 120 (near the pain threshold) represents a pressure which is a million million (10^{12}) times the reference level.

Since the human ear detects sound in a nonlinear fashion over the audible frequency range of 16 to 16,000 Hz (cycles per second), the decibel unit must be weighted differently for each frequency. Of the various weightings available, it is accepted that so-called A-weighting, denoted as dbA, is the most practical measure of noise produced by today's highway vehicles. It correlates as well with human judgements of the acceptability of highway noise as do the more elaborate spectral analysis methods.

Knowledge of the average traffic noise level is not, in itself, necessarily sufficient if one is to define environmental acceptability. Some knowledge of the noise peaks and distribution is also required. Although several concepts have been proposed for characterizing these peaks and the distribution, it has been decided that the noisier aspects of the traffic environment can be adequately defined using the temporal unit, L_{10}. This is the noise level which is exceeded 10 percent of the sample time.

Two methods for determining the L_{10} level have been approved by the Federal Highway Administration in PPM 90-2, "Noise Standards and Procedures," effective January 29, 1973. These approved methods are:

1) National Cooperative Highway Research Program Report 117, "Highway Noise: A Design Guide for Highway Engineers," 1971.

2) DOT Transportation Systems Center Report DOT-TSC-FHWA-72-1, "Manual for Highway Noise Prediction," March, 1972.

Since these methods require access to a computer and may be more complex than necessary for the preliminary prediction purposes of most city and county groups, it was concluded that a set of curves covering the proper variables would be more appropriate and useful.

At the request of the Department's Local Government Division, and as the result of discussions with their personnel, certain parameters and ranges were established as those which would best satisfy most of the noise prediction needs of city and county highway agencies.

The parameters and ranges established are:

1) DN - Distances between observer and center of near lane of 15, 30, 45, 60, and 75 ft
2) Q - Flow rates of 600 to 3,000 vehicles/hour
3) S - Vehicle speeds of 20, 30, 40, and 50 mph
4) P - Non-divided pavements of 2, 3, 4, and 5 lanes
5) T - Commercial[1] traffic volumes of 1 to 10 percent.

There are several rules-of-thumb for estimating changes in noise levels when only one parameter such as distance (DN) or flow rate (Q) varies. In the case of a modified line source traffic model (as opposed to an individual vehicle point source) we have:

1) The doubling of flow rate (Q) increases L_{10} by 3 db
2) The doubling of distance (DN) decreases L_{10}, on the average, by 4.5 db (3 dbA minimum to 6 dbA maximum).

If there are two noise sources and the noise power of each is known, decibel levels are not directly added to get the total sound level. Instead, one must convert from decibels to sound pressures, add the pressures, and then reconvert to decibels. For example, if an automobile which is radiating a level of 80 dbA (as measured from some fixed distance) is located next to an identical automobile also radiating 80 dbA, the resultant noise field will have twice the power. This will not produce 160 dbA, but only 83 dbA, as doubling the power adds only 3 dbA to the existing level. If the power is doubled again by adding two more such vehicles, the net result would be 86 dbA. Again doubling (for a total of eight such vehicles) would result in a total of 89 dbA, and further doubling (sixteen vehicles) would add another 3 dbA to the level for a total of 92 dbA. Therefore, in a hypothetical situation it would take 16 automobiles, each emitting 80 dbA to equal one truck which is emitting 92 dbA.

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[1] Commercial being defined as a motor vehicle having a gross vehicle weight greater than 10,000 lb and buses having a capacity exceeding 15 passengers.

The graphs presented in this report (Figs. 1, 2, 3, and 4) for estimating L_{10} (dbA) noise levels are based on the Department's computer version of the modified line source model of NCHRP Report No. 117. There is one inherent problem in using this noise prediction method for low volume traffic conditions. The graphed relationships in that report relating car and truck volumes and speeds, to noise level, and for adjusting results to the L_{10} parameter, do not extend sufficiently to cover many low commercial volume situations. To overcome this deficiency the FHWA has suggested that each truck in a low commercial volume traffic stream be replaced in the model by 15 cars. This suggestion has been adopted and used in constructing the prediction graphs of this report.

Using this technique does produce, in some cases (5 and 10 percent commercial), a step at the boundary between the prediction curves and their computer-extrapolated segments. These steps have been subjectively adjusted by an experienced engineer-acoustician to give smooth, continuous curves. Admittedly, this is not an ideal technique, but it should produce best state-of-the-art predictions until such time as a large mass of quantitative measurement data have been accumulated, enabling the objective extension of the volume versus sound level relationships.

The nearly constant +3 dbA L_{10} difference (specified on Figs. 1 through 4) between the 1 percent and 5 percent and between the 5 percent and 10 percent commercial traffic volumes -- over the specified observer distances, vehicle flow rates, and vehicle speeds -- is derived from Section 3 of the DOT-TSC-FHWA prediction method mentioned earlier.

Also, an interrupted flow adjustment of +2 dbA has been specified for observer points near a traffic signal or stop sign. Users of the prediction graphs are directed to add 2 dbA to the graphed L_{10} values whenever the site in question is within 300 ft of a controlled intersection.

Levels at an observer point receiving noise from two or more different roadway sources, such as a divided city street or in a quadrant of an intersection, can be determined by "db addition" of the levels from each individual source as discussed in the Appendix.

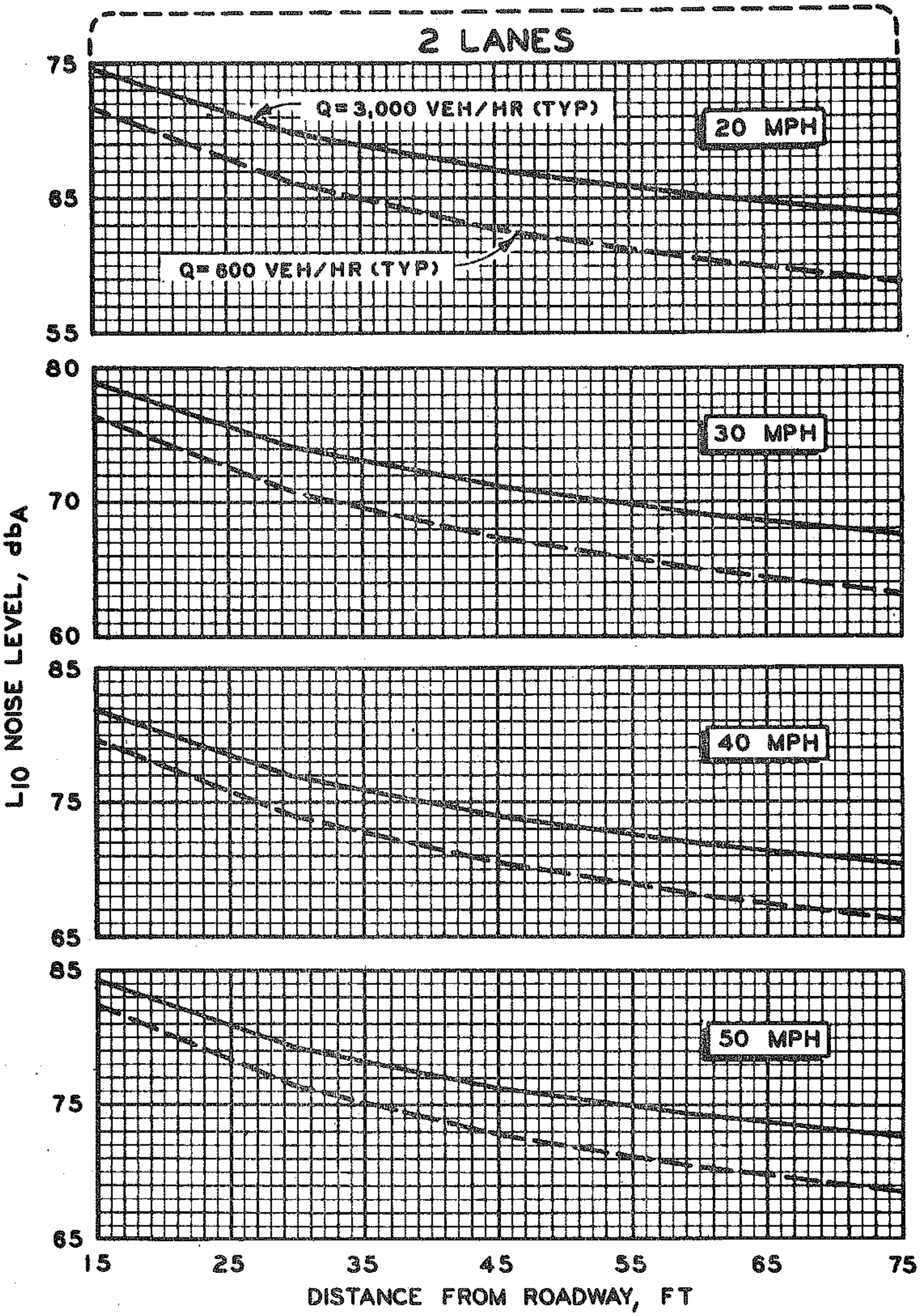

Figure 1. Noise estimation[1] curves for locations near at-grade roadways with 1 percent commercial traffic. For 5 percent commercial, add 3 dbA. For 10 percent commercial, add 6 dbA. For sites within 300 ft of controlled intersection, add 2 dbA.

[1] Based on the Michigan Noise Predictor Computer Program of the method of NCHRP Report No. 117.

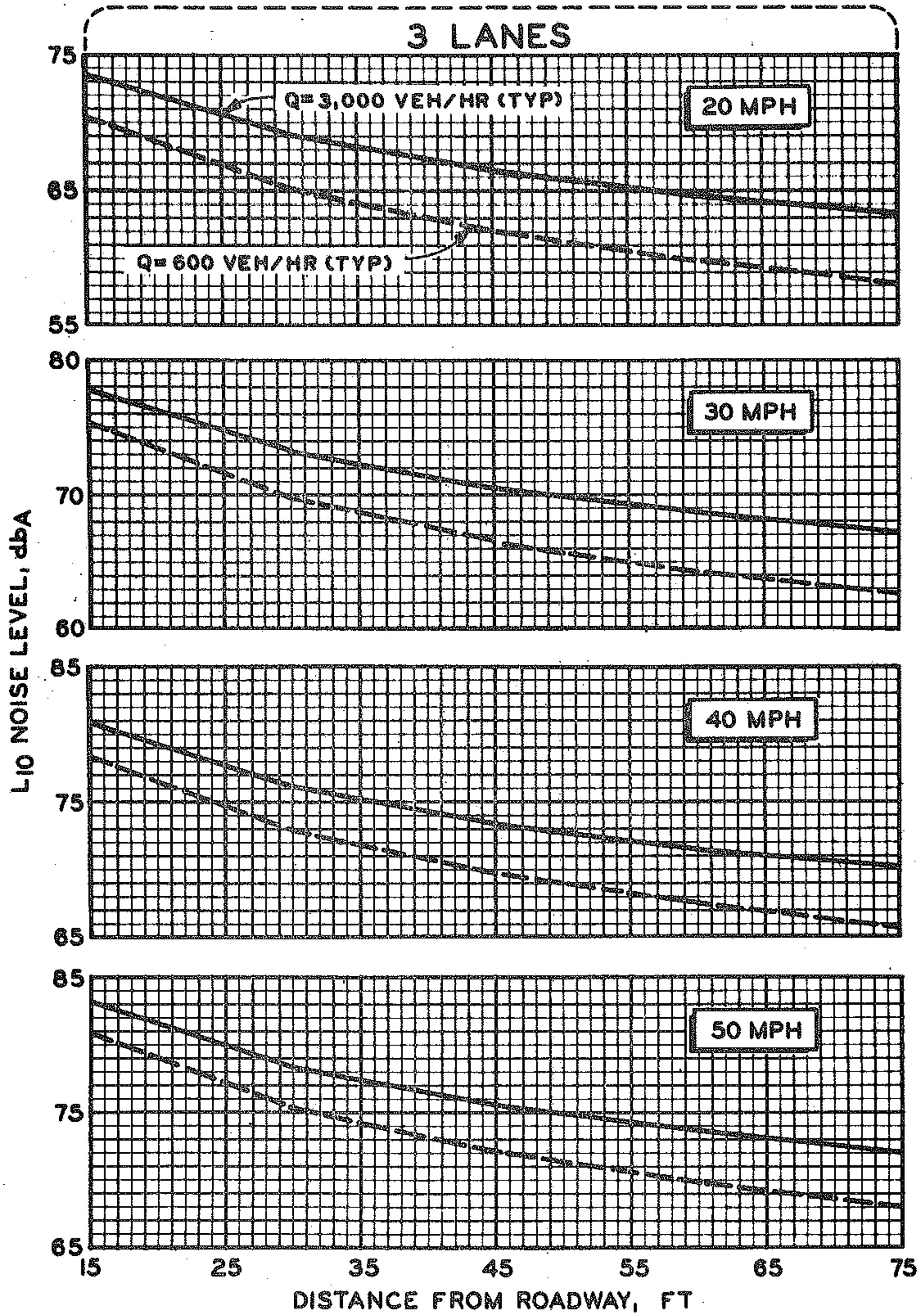

Figure 2. Noise estimation[1] curves for locations near at-grade roadways with 1 percent commercial traffic. For 5 percent commercial, add 3 dbA. For 10 percent commercial, add 6 dbA. For sites within 300 ft of controlled intersection, add 2 dbA.

[1] Based on the Michigan Noise Predictor Computer Program of the method of NCHRP Report No. 117.

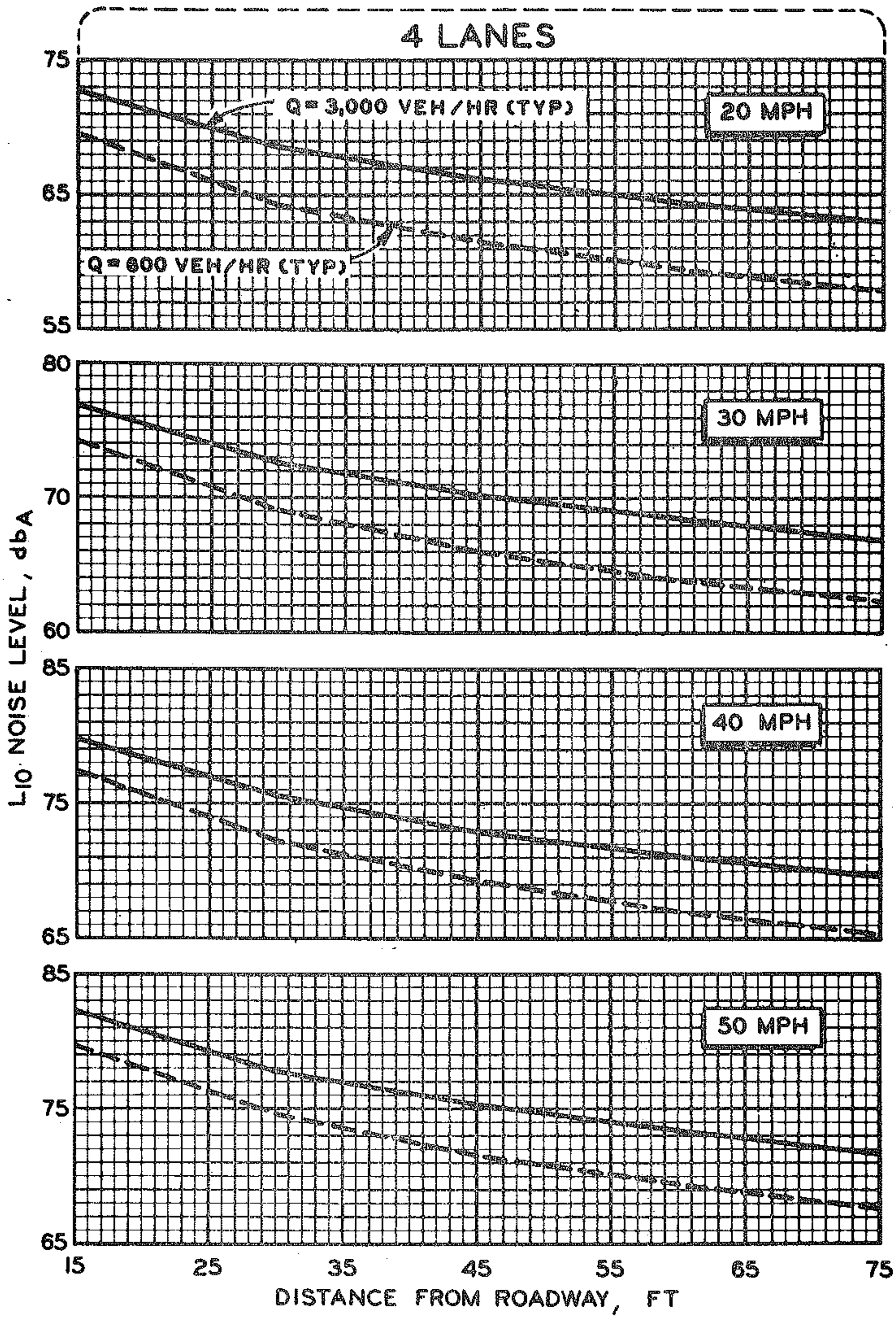

Figure 3. Noise estimation[1] curves for locations near at-grade roadways with 1 percent commercial traffic. For 5 percent commercial, add 3 dbA. For 10 percent commercial, add 6 dbA. For sites within 300 ft of controlled intersection, add 2 dbA.

[1] Based on the Michigan Noise Predictor Computer Program of the method of NCHRP Report No. 117.

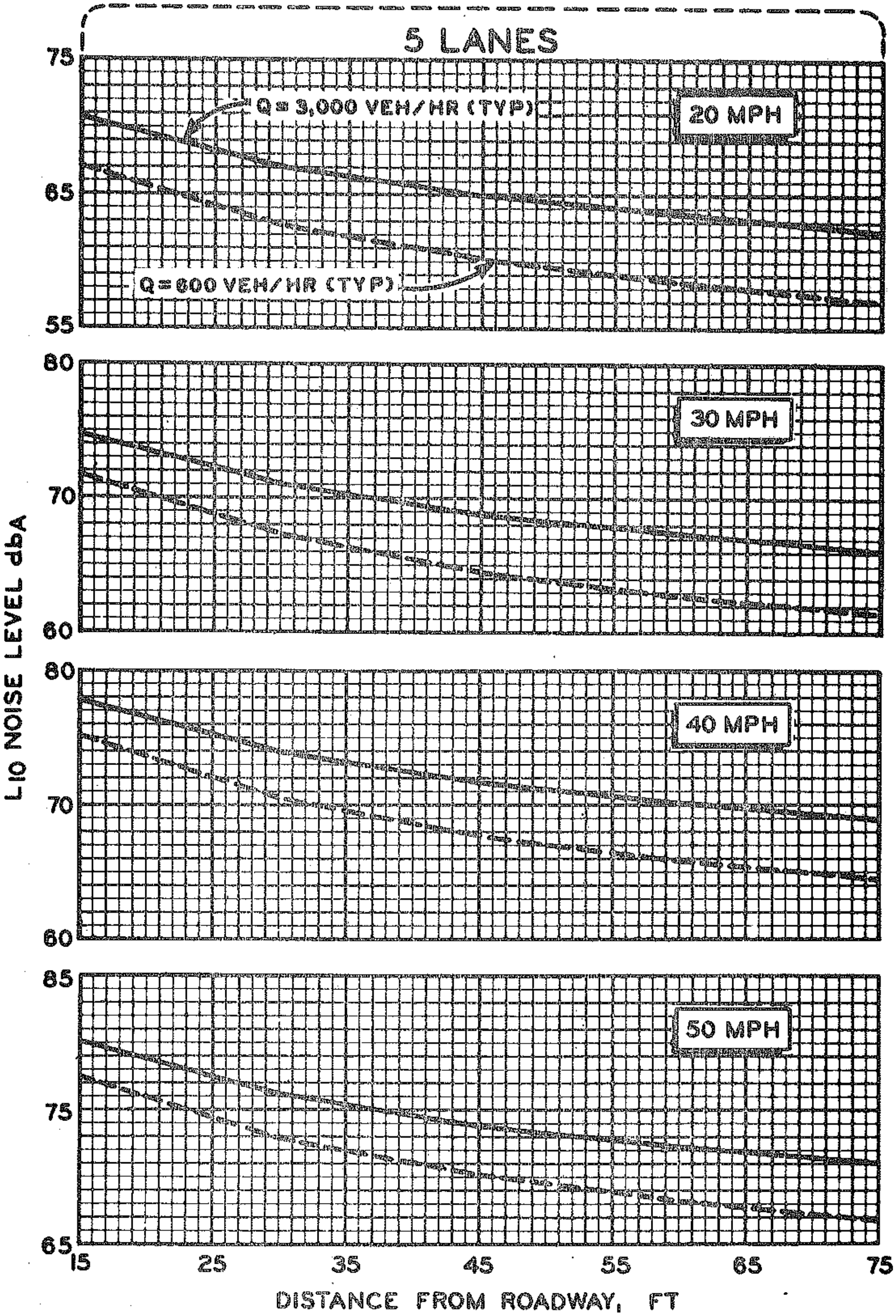

Figure 4. Noise estimation[1] curves for locations near at-grade roadways with 1 percent commercial traffic. For 5 percent commercial, add 3 dbA. For 10 percent commercial, add 6 dbA. For sites within 300 ft of controlled intersection, add 2 dbA.

[1] **Based on the Michigan Noise Predictor Computer Program of the method of NCHRP Report No. 117.**

APPENDIX

ADDITION OF DECIBEL LEVELS

The addition of decibel levels is accomplished by use of the Figure A-1 graph as follows:

1. Call the larger level A, the smaller B.
2. Find the numerical difference between A and B, i.e., A - B.
3. Enter the graph on the absicissa (x) at A - B. On the ordinate (y) read C.
4. Add the numerical sum of A plus C to obtain the true combined decibel level, D.

EXAMPLE:

1. A = 83 db, B = 77 db
2. A - B = 6 db
3. C = 1 db
4. D = A + C = 83 + 1 = 84 db

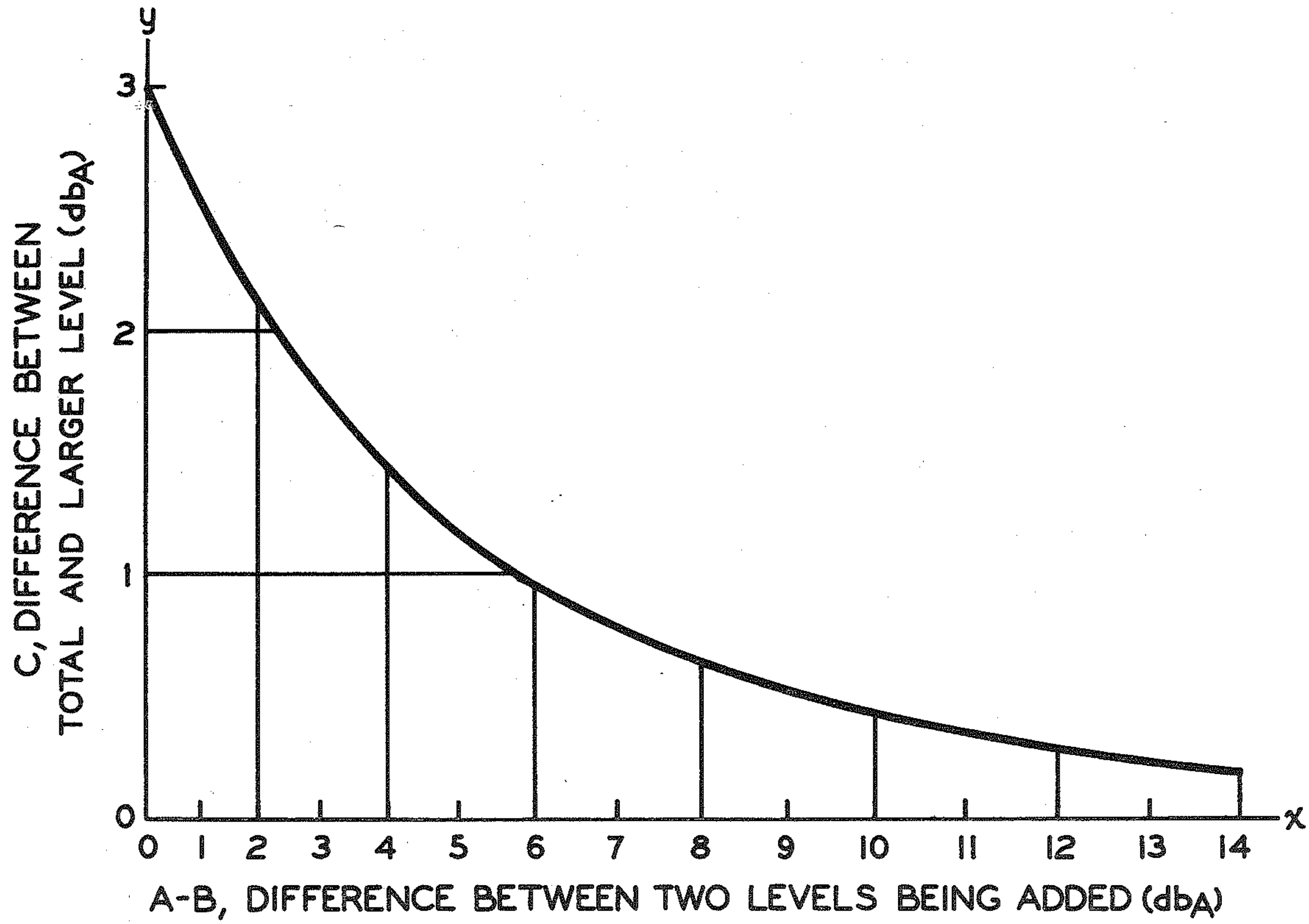

Figure A-1. Summing Decibel Levels