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Propagation of Urban Construction Site Noise Along Street Corridors

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*
Jordan J. Baruch, *Assistant Secretary for Science and Technology*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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1. INTRODUCTION

Estimates of the U. S. Environmental Protection Agency indicate that 103 million Americans experience environmental or community noise from various sources including construction sites.[1] In the assessment of possible impact of urban construction site noise, it is necessary to have an estimate of the attenuation of sound along the propagation path between the source and the receiver. The attenuation of noise from construction sites in urban areas depends on a number of parameters of which street geometry is the most significant.

The current report addresses construction site noise propagation along urban street corridors for two different city block configurations, as well as five different construction site orientations relative to a major street intersection. The conceptual propagation model and the computer programs used to estimate urban street corridor sound propagation are presented along with the resultant sound fields determined for the ten configurations studied.

2. THE URBAN PROPAGATION MODEL

Urban sound propagation is complicated by many factors including spherical divergence, excess ground and atmospheric attenuation, multiple reflections from building surfaces, shielding by buildings, and scattering from the building surfaces. Multiple reflection of sound in city streets creates both local reverberation and the ability of sound to propagate around corners. The shielding effect of buildings constrains the sound radiated by individual sources to propagate along street channels while substantially reducing the sound incident on building surfaces not exposed to the street channel. The scattering of sound from building surfaces alters the distribution of sound energy along streets from that predicted from multiple reflection alone and markedly increases the extent by which sound propagates around corners.

In calculations of the contribution of multiple reflection in urban sound propagation, it is useful to employ the geometrical acoustics limit which requires the acoustic wavelength to be much smaller than the typical geometric length scales associated with the propagation problem. In a gross sense, this requirement is usually satisfied in urban areas as the wavelengths of importance to A-weighted sound levels are typically about 1.3 m (250 Hz.) to .17 m (2000 Hz.) while street dimensions are generally 15 m (50 ft) or more. With this simplifying assumption, sound propagation due to specular reflection in idealized street channels has been studied by several researchers [2-7]. Good quantitative agreement between the geometric acoustics approximation and acoustic data from physical scale models for smooth, acoustically hard street channels has also been demonstrated [2, 7]. However, application of this theory to field data of sound propagation in actual city streets (e.g., Refs. 8 and 9) indicates that the predicted sound levels (using wall absorption coefficients consistent with exterior building materials) are substantially higher than those measured [10, 11].

The discrepancy between field data and the specular reflection, geometric acoustics model of urban sound propagation is attributable to the scattering of sound from building surfaces. A closer examination of most building surfaces reveals that the surfaces often contain many irregularities formed by doorways, window recesses, and other facade elements. The depth and width of these surface protrusions (and/or recesses) are typically on the order of the acoustic wavelengths of interest. Thus, reflection from actual building surfaces is complex and involves not only a specular component of reflection, but also a scattered component.

The effect of rectangular surface irregularities in modifying the sound distribution in street channels relative to the smooth wall idealization has been demonstrated in studies using acoustic models [5, 7]. These studies revealed that the presence of surface protrusions significantly reduced (5-10 dB) the sound levels in the street channels at distances of about three or more streets away from the source while the sound levels near the source were slightly increased (1-2 dB) [7]. This trend was found to be more nearly consistent with the urban sound propagation field data reported.

As part of a study to develop a more suitable urban propagation model which would include surface scattering, an empirical investigation of reflection and scattering from surfaces with rectangular protrusions was conducted [11]. This investigation determined that the amount of energy specularly reflected from such surfaces was dependent on incident angle. The angularly dependent reflection coefficient (defined as the ratio of the reflected energy to the incident energy) as determined in this study is presented in Fig. 1. In addition to determining an angularly dependent reflection coefficient, the magnitude and angular dependence of the scattered sound was also obtained. For the range of protrusion configurations typically occurring on actual building surfaces, it was further shown that reflected and scattered energy were not significantly dependent on the details of the surface geometry or on frequency for octave bands of noise between 250 and 2000 hertz.

Using the results of this surface reflection investigation, a comprehensive model of urban sound propagation was developed [11]. This model is conceptually similar to the geometrical acoustic limit model discussed earlier; however it incorporates angularly dependent reflection from building surfaces and accounts for the energy scattered upon reflection. As part of the development of this model, quantitative agreement was demonstrated between predicted sound level, field data, and acoustical model data. The propagation model was used to develop a number of computer programs applicable to propagation cases arising from the common "grid pattern" street configuration. These cases include propagation from a single intersection, propagation from one intersection through another, and propagation into the street of the second intersection. For single intersections, the cases of four-way, tee and open (half of a four-way) intersections were also programmed. With these cases, the sound levels in streets surrounding the street containing a noise source can be determined, as illustrated in Fig. 2. In applying these computer programs it should be noted that the following assumptions are necessary:

- the streets are continuously lined with buildings
- spacings between adjacent buildings are not greater than 1/4 street widths
- building height is a least 1 street width
- street width is at least 1 order of magnitude greater than the acoustic wavelength of interest

3. COMPUTED VALUES OF NOISE ATTENUATION FOR URBAN CONSTRUCTION SITES

The computer programs discussed in Section II were used to estimate noise propagation from construction sites for two different grid pattern urban street geometries. The first case considered was square city blocks which were 180 m (600 ft) on end. The second case was rectangular city blocks which were 90 m (300 ft) wide and 180 m (600 ft) long. For the first case three site locations were used. These sites and the street geometries are presented in Figs. 3 and 4. The site illustrated in Fig. 3 was located in a street channel while those of Fig. 4 were located in an undeveloped (no buildings) block. For the second block configuration case two site locations were used as illustrated in Figs. 5 and 6. The site in Fig. 5 was located at a fourway intersection and the site of Fig. 6 was in a partially developed block such that buildings were assumed to be present everywhere in the block accept in the 60 m (200 ft) by 60 m site.

In applying the urban propagation computer programs to some of the specific construction noise propagation cases of Figs. 3 through 6, some approximations to site and street geometry were required. For the propagation cases of Fig. 3, attenuations in all streets except Street 1b could be computed directly. Because the existing computer programs do not include propagation through two intersections, it was necessary to determine attenuations in Street 1b by assuming the intersection of Street 2 was not present and that the only intersecting street between the site and the receiver street (1b) was the Street 3 intersection. Although the error associated with this approximation can not be quantitatively assessed within the scope of present effort, it is anticipated that this approximation would introduce no more than a 1 or 2 dB error in the attenuation values in Street 1b relative to the actual geometric configuration. In order to compute attenuations for the sites of Fig. 4, it was necessary to assume the geometry illustrated in Fig. 7. Although the absence of buildings on either side of the block containing the construction site physically appears quite different from the geometry of Fig. 4, acoustically, the absence of these buildings will cause only minimal effects in Streets 1 and 3 since, because of their orientation, these buildings do not contribute to the specularly reflected energy in the streets of interest. The assumed geometry of Fig. 7 is anticipated to have no more than about 1 dB effect on the attenuation values in Streets 1 and 3 relative to the actual site geometries of Fig. 4. An analogous geometry to that of Fig. 7 was used to determine attenuation values for Street 2 of Fig. 4.

For the Case II site and street geometries of Fig. 5, the existing computer programs could be applied directly to determine attenuation values in all streets except Streets 1c and 3. As was necessary for Street 1b of Site A Case I, to determine attenuation values in Streets 1c and 3 of Fig. 5, it was necessary to omit the intervening intersection of Street 2 with Street 1. Again, the effect of this approximation is (should be) minimal. In order to apply the computer programs to the propagation cases of Fig. 6, a similar approximation to that used for Sites B and C of Case I (Fig. 7) was required. However, for this case, since buildings surround the site, the width of the expanded street containing the site is one street width (23 m) plus the site width (60 m) rather than two streets plus one block width as was done for Case I. This assumed geometry is presented in Fig. 8 as it applies to Streets 1, 2 and 3 of Site B, Case II (Fig. 5). As was stated in regard to the corresponding Case I approximation, it is anticipated that the assumed geometry of Fig. 8 will not appreciably effect the calculated attenuation values (no more than about 1 dB) due to the lack of contribution from the omitted buildings to the reflected energy in Streets 1, 2, and 3. A geometry analogous to that of Fig. 8 was used to determine attenuation values in Streets 4 and 5 of Site B, Case II (Fig. 6).

Using the site geometries discussed above as needed, noise attenuation values for the various sites for each of the block configurations were computed. The attenuation values for Case I are presented in Tables 1 through 7 for Sites A, B, and C. These attenuation values are applicable to A-weighted sound level for the construction noise spectral data shown in Figure 9 and to octave band levels for center frequencies from 250 to 2,000 hertz. It will be noted that distance along streets is presented normalized by the street width, or 23 m (75 ft). This was done since the results are equally applicable to any geometrically similar propagation case (i.e., in Case I, the values given would be identical to any configuration of square blocks where the ratio of block length to street width was 8 to 1 and the source location was similar). was 8 to 1 and the source location was similar). It will also be noted that the distances in Tables 3, 5, and 6 correspond to the distances along the street from the perpendicular projection of the site location onto the street centerline. The attenuation values of Tables 1 through 7 are also plotted in Figs. 10, 11, and 12. For these plots, distance is taken to be the distance from the site to the street channel plus the appropriate distance along the channel(s). Using this distance measurement, all the attenuation values for one site could be shown on the same plot. In addition to the urban attenuation values, the ideal free field attenuation rate of 6 dB per doubling of distance is also indicated in each of Figs. 10, 11, and 12. The location of the intersection openings is also provided in the plots along the distance scale.

The attenuation values for Block Configuration Case II are presented in Tables 8 through 15. The distance values for Site B were determined in the same manner as those for Case I, Sites B and C. Attenuation versus distance from the site for Case II is plotted in Figures 13 through 16 for Sites A and B. In addition to plotted free field attenuation as in Figures 10-12, the attenuation values for Streets 1 and 4 of Site A and Streets 1 and 4 of Site B are plotted for the case of no intervening intersections between the site and the receiver point. These values were included to demonstrate the effect of the intervening intersections on the attenuation values down the respective streets. Examination of these curves in Figs. 13-16 reveals that the effect of the presence of the intersection is to increase the attenuation after the intersection by about 1 to 2 dB relative to no intervening intersection.

Inspection of the attenuation plots in Figs. 10-12 and Figs. 13-16 leads to several conclusions relevant to urban propagation of construction noise. On those streets where a line-of-sight is maintained with the site (i.e. Street 1 of Case I, Site A and Streets 1 and 4 of Case II, Site A) the observed sound level is substantially higher than the corresponding free-field sound level. This elevation in level ranges from 2 to 10 dB, depending on distance from the site for these streets. Further, for these streets, the attenuation versus distance values are nearly identical, falling within about 1 to 2 dB of each other. For those streets in which the site is offset from the street channel (i.e. Streets 1 and 2 for Case I, Sites B and C, and Streets 1 and 4 for Case II Site B) attenuation versus distance is quite close to attenuation versus distance due to spherical divergence (6 dB/doubling of distance). For these streets, the attenuation values are typically within 3 dB of the free-field values and within 5 dB of each other. Finally, for those streets in which the sound propagates initially down a street channel and then around a corner (i.e. for Case I, Streets 2 and 3 for Site A, Street 3 for Sites B and C; for Case II, Streets 2, 3, and 5 for Sites A and B) the attenuation values increase very rapidly with distance from the site. In most cases this attenuation is between 35 and 40 dB at distances of less than 20 street widths from the site.

Application of the attenuation values in Tables 1-15 and in Figs. 10-16 can be readily made to determine sound levels in streets due to a particular known source. The steps required to determine these sound levels are:

1. Calculate the source noise level at one street width. This is done by subtracting 20 times the logarithm (to the base ten) of the street width divided by the distance for which the free-field source level is specified.
2. Determine the normalized distance between the site and the receiver point of interest by dividing the distance by the street width.
3. Using the normalized distance, find the attenuation value corresponding to that distance.
4. Subtract the the attenuation value from the source noise level at one street width to determine the noise level at the point of interest.

As an example of this procedure, suppose it is desired to determine the A-weighted sound level 270 m (900 ft) from the construction site of Figure 5 in Street 4b. Further, the source is known to have an A-weighted sound level of 82 dB at 15 m (50 ft). Following the steps outlined above:

1. The source level at one street width is (expressed in feet) -

$$82 - 20 \text{ LOG } \frac{75 \text{ ft}}{50 \text{ ft}} = 78.5 \text{ dB}$$

2. The normalized distance between site and receiver point is (in feet) -

$$\frac{900 \text{ ft}}{75 \text{ ft}} = 12 \text{ STREET WIDTHS}$$

3. From Figure 13, the attenuation at 12 street widths for Street 4b is about 12 dB
4. The A-weighted sound level at the receiver point is therefore -

$$78.5 - 12.0 = 66.5 \text{ dB}$$

A more direct approach to applying the attenuation values of Figs. 10-16 is simply to adjust the scales of the plots to correspond to the specific case of interest. Assuming the same source noise levels as in the above example, the attenuation values of Fig. 14 have been converted to A-weighted sound levels as a function of distance in meters and are presented in Fig. 17. It will be noted the 0 dB attenuation value at one street width in Fig. 14 corresponds to the A-weighted sound level of 78.5 dB at 23 m in Fig. 17 as determined in the previous example.

In addition the propagation cases of Figs. 3-6, an attempt was made to assess the penetration of sound into and through city blocks due to alleyways in the blocks. An example of the geometry used to attempt such an assessment is given in Fig. 18 for Block Configuration Case II, Site A. It should be noted that the assumed alleyway width is 4.6 m (15 ft), which is not an order of magnitude greater than the longest acoustic wavelength of interest, that is, 1.3 m for 250 hertz. This criteria is only met at

1000 hertz and above. Therefore, the attenuation values determined by the propagation model can not be confidently applied to 250 and 500 hertz octave-band sound levels or to A-weighted sound levels for the construction noises represented in Fig. 9. In order to have reliable prediction of attenuation values at these frequencies for a 4.6 m alleyway, the existing propagation model would have to be verified emperically for this case and/or expanded to include the wave properties of sound propagation for this narrow channel width.

Although there are limitations on applying the results, the calculated attenuation values for the alleyway configuration of Fig. 18 are plotted in Fig. 19. Also plotted in Fig. 19 are the attenuation values in Streets 1 and 4 of Site A Case II in the vicinity where the alleyways intersect each respective street. It will be noted that the alleyway attenuation values increase with distance in much the same manner as noted earlier for Streets 2a, 2b, 3a and 3b of Site A Case II (Fig. 13). The attenuation values of Fig. 19 indicate, that at least for higher frequencies, penetration of noise into the block along alleyways may be significant and may result in some noise impact. However, because of limitations of the propagation model in predicting A-weighted attenuation for such narrow channels, no definitive statement about noise levels along alleyways can be made based on the values of Figure 19.

4. SUMMARY OF RESULTS

The urban sound propagation model described in Section II of this report has been applied to several urban configurations to determine attenuation in street corridors near construction sites. The resultant sound level attenuation values presented in Section III can be summarized with several general observations. The first of these observations is that the sound levels and attenuation rate in the street corridors are dependent on the position of the construction site relative to the corridor opening. When the site is located directly in the street opening, the sound level attenuation rate is about 3.5 dB per doubling of distance along the street. This rate can be approximated by a cylindrical divergence model of channel propagation with some excess attenuation as has been indicated in previous studies [2, 8]. Further, because this rate is lower than the spherical divergence (6 dB/DD) rate that would occur in a idealized open area, the sound level in the street is higher than would be expected in an open area by as much as 10 dB at distances greater than about ten street widths. When the site is offset from the street corridor opening, the sound level attenuation rate is approximately 6 dB per doubling of distance along the street and hence more closely approximates the attenuation rate associated with spherical divergence. For these cases, although the attenuation rates are similar, the sound levels in the streets are typically offset slightly higher than would be expected in a free-field environment by as much as 4 dB.

The second set of observations concerns propagation through and around intervening intersections located between the site and the street of interest. When the propagation path is directly through the intersection, the sound levels in the street past the intersection are only slightly lower (1 to 2 dB) than would be expected if the intersection were not present. However, when the propagation path includes turning a corner at the intervening intersection, the sound levels in the street around the corner are substantially lower than the sound levels in the street for which the propagation path is directly through the intersection. The difference in sound level between these two streets is initially about 2 to 5 dB near the intersection decreasing to as much as 15 to 18 dB before the next intersection.

REFERENCES

1. Federal Research, Development and Demonstration Programs in Machinery and Construction Noise, Federal Interagency Machinery and Construction Noise Research Panel (Report U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C., February, 1978.)

2. Schlatter, W. R., "Sound Power Measurements in a Semi-Confined Space," M. Sc. Thesis (Massachusetts Institute of Technology, Cambridge, Mass., July, 1971.)

3. Pande, L., "Model Study of Aircraft Noise Reverberation in a City Street," U. S. Department of Transportation Interim Report, Contract DOT-TSC-93 (Massachusetts Institute of Technology, Department of Mechanical Engineering, Cambridge, Mass., April, 1972.)

4. Kinney, W. A., and Pierce, A. D., "Helicoptor Noise Experiments in an Urban Environment," 56, 332-337 (1974).

5. Donavan, P. R. and Lyon, R. H., "A Model Study of the Propagation of Sound from V/STOL Aircraft into Urban Environs," Proc. Second Interagency Symposium on University Research in Transporation Noise, 505-519 (North Carolina State University, Raleigh, N.C., June 1974).

6. Lee, K. P., and Davies, H. G., "Nomogram for Estimating Noise Propagation in Urban Areas," J. Acous. Soc. Amer., 56, 1477-1480 (1975).

7. Donavan, P. R., and Lyon, R. H., "Sound Propagation Near Ground Level in the Vicinity of Street Intersections," Proc. Second Interagency Symposium on University Research in Transportation Noise, 491-504 (North Carolina University, Raleigh, N. C., June 1974.)

8. Wiener, F. M., Malme, C. I., and Gogos, C. M., "Sound Propagation in Urban Areas," J. Acous. Soc. Amer. 37, 738-747 (1965).

9. Delaney, M. E., Copeland, W. C. and Payne, R. C., "Propagation of Traffic Noise in Typical Urban Situations," NPL Acoustics Report, No. AC 54 (October 1971).

10. Lyon, R. H., "Role of Multiple Reflection and Reverberation in Urban Noise Propagation," J. Acous. Soc. Amer., 55, 493-503 (1974).

11. Donavan, P. R., "Sound Propagation in Urban Spaces," Sc. D. Thesis (Massachusetts Institute of Technology, Department of Mechanical Engineering, Cambridge, Mass., January 1976.)

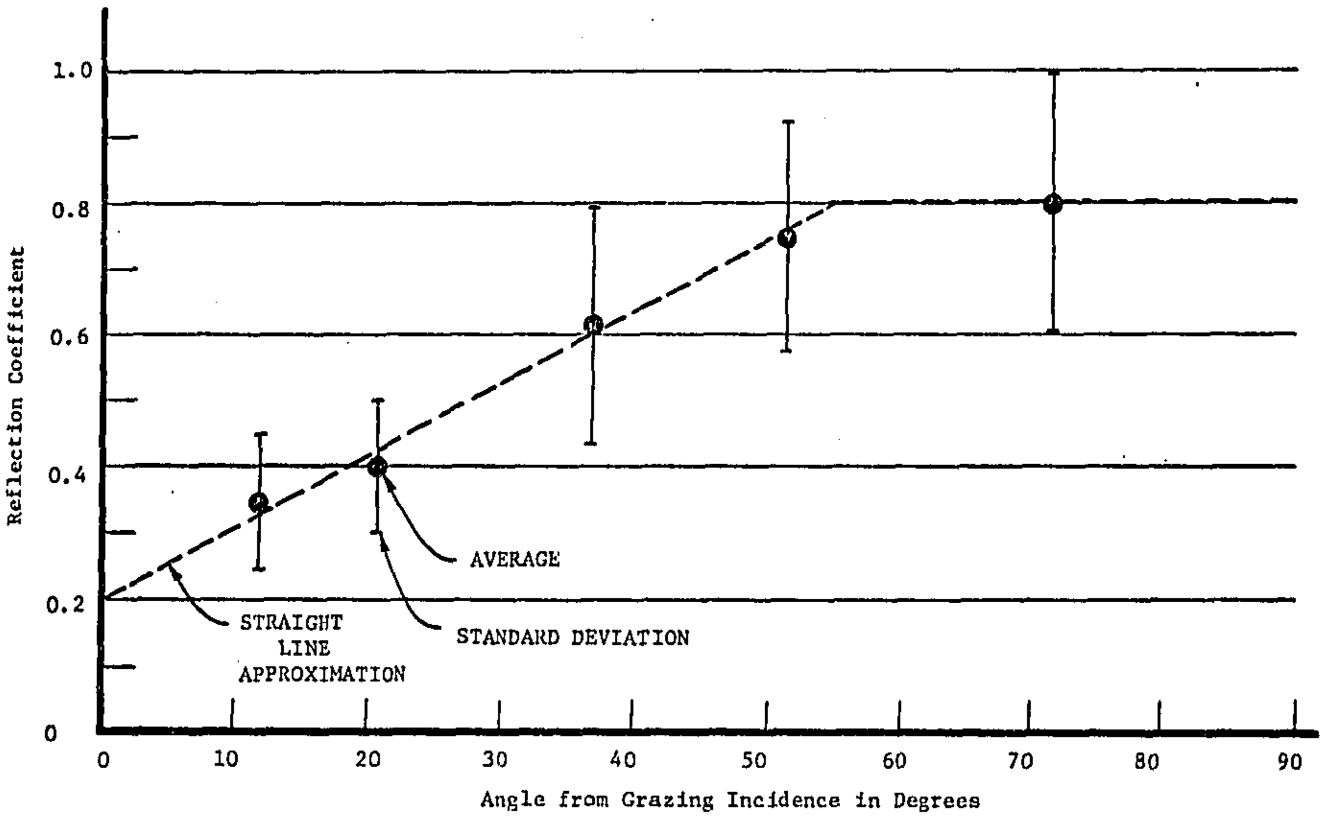

Figure 1: Measured Reflection Coefficients with Two Segment Linear Approximation Averaged for Frequencies Corresponding to 250, 500, 1000, 2000 hertz (From Reference 11)

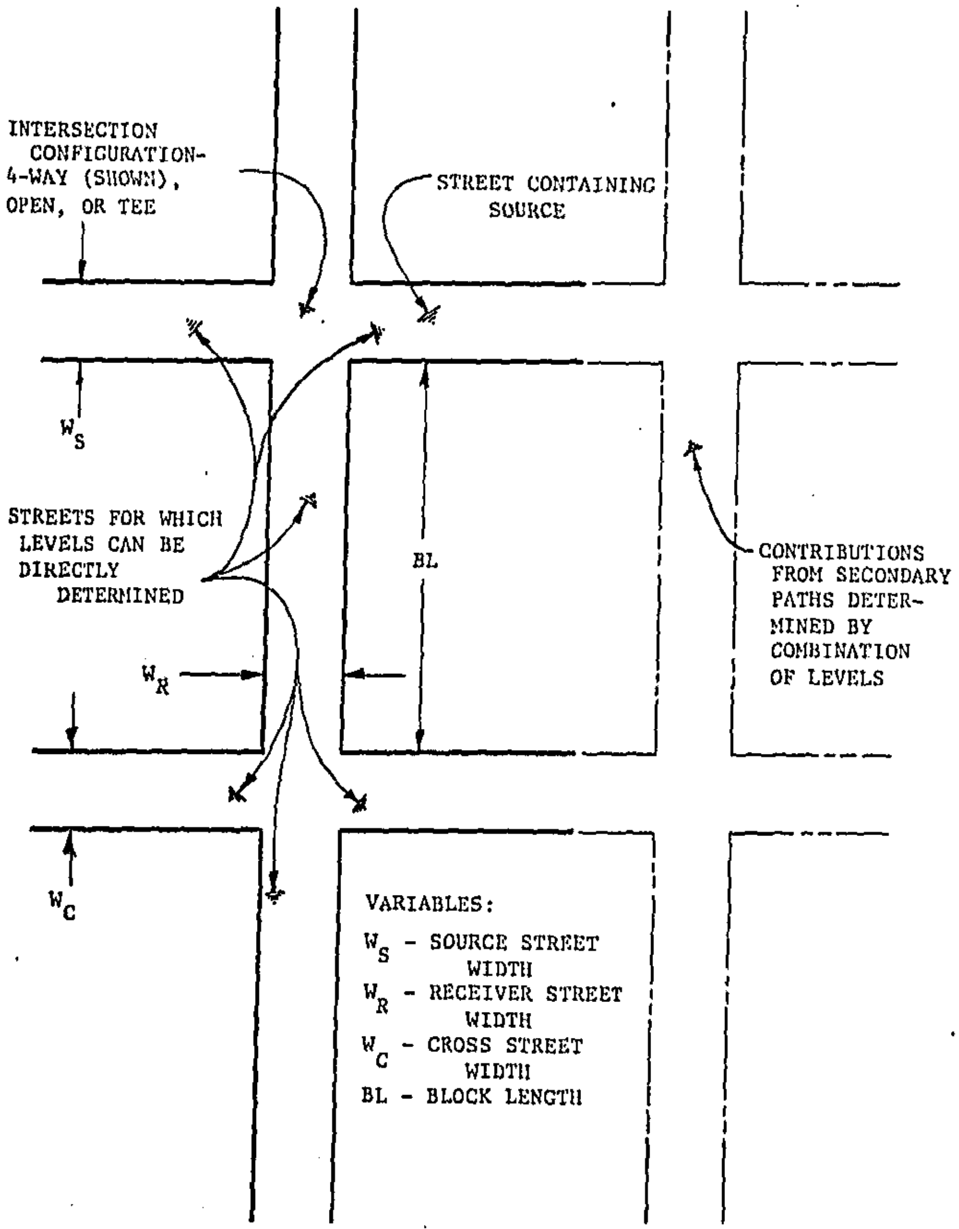

Figure 2: Applicability of Urban Sound Propagation Computer Programs (From Reference 11)

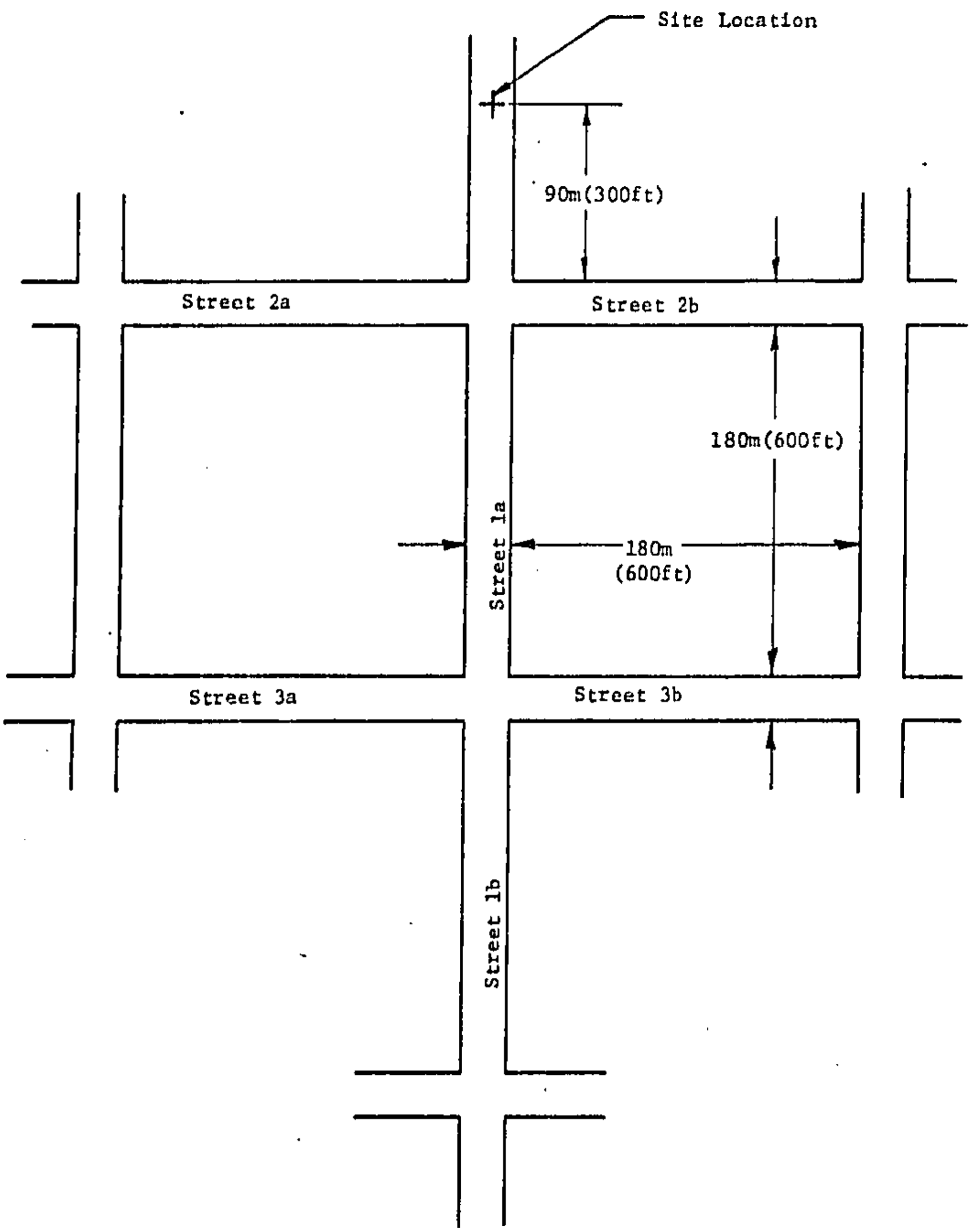

Figure 3 : Geometry and Nomenclature for Block Configuration Case I, Site A.

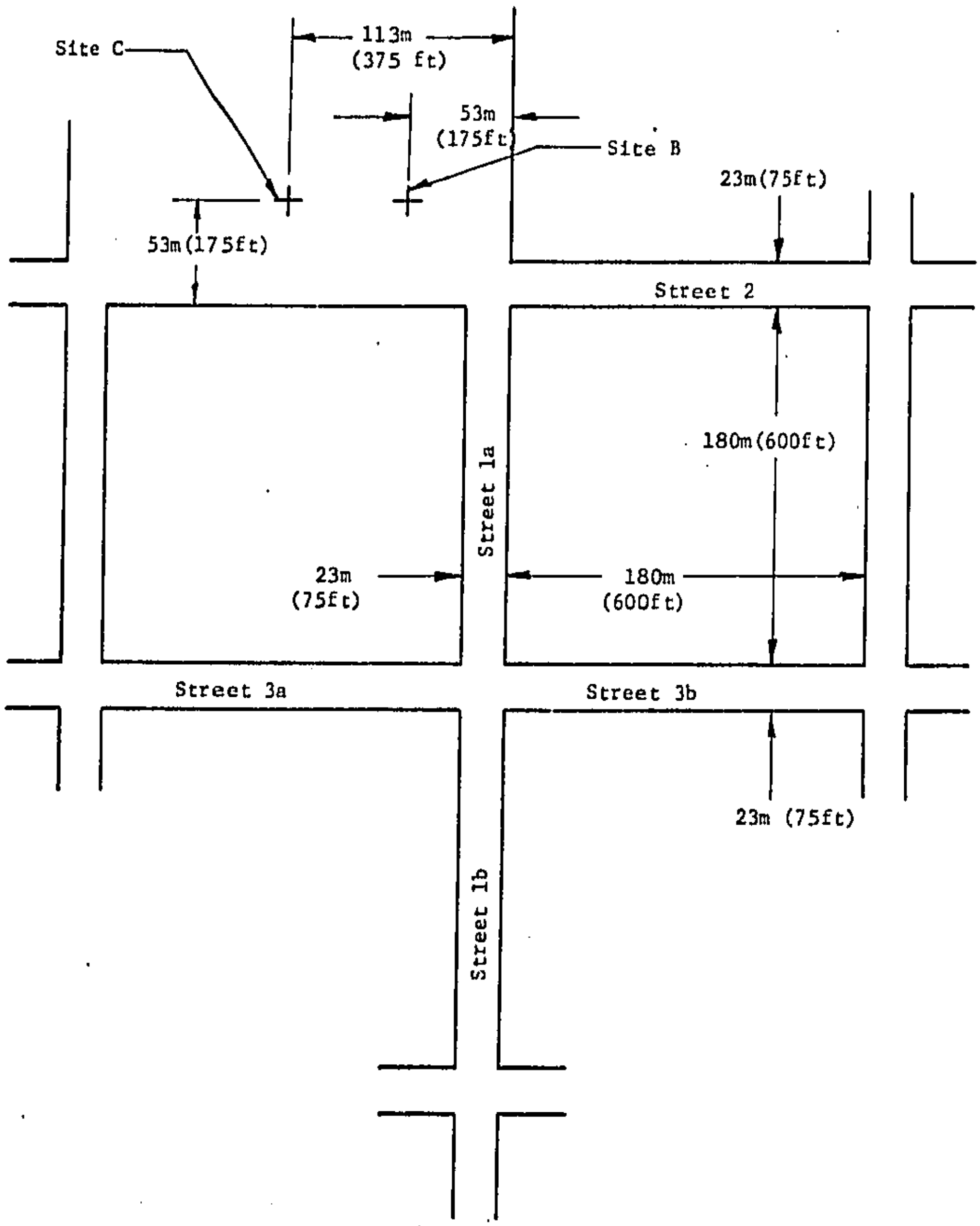

Figure 4 : Geometry and Nomenclature for Block Configuration Case I, Sites B and C.

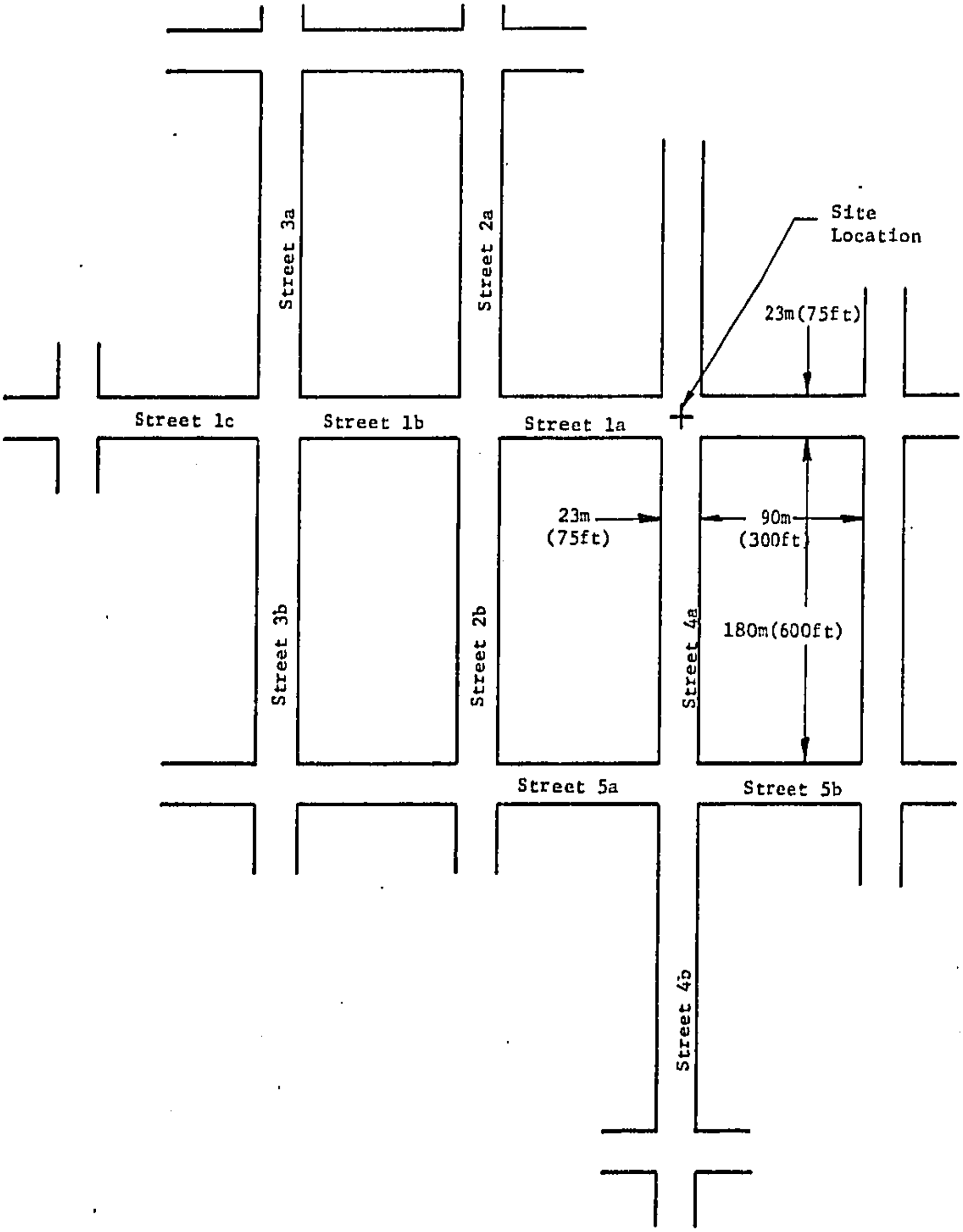

Figure 5 : Geometry and Nomenclature for Block Configuration Case II, Site A.

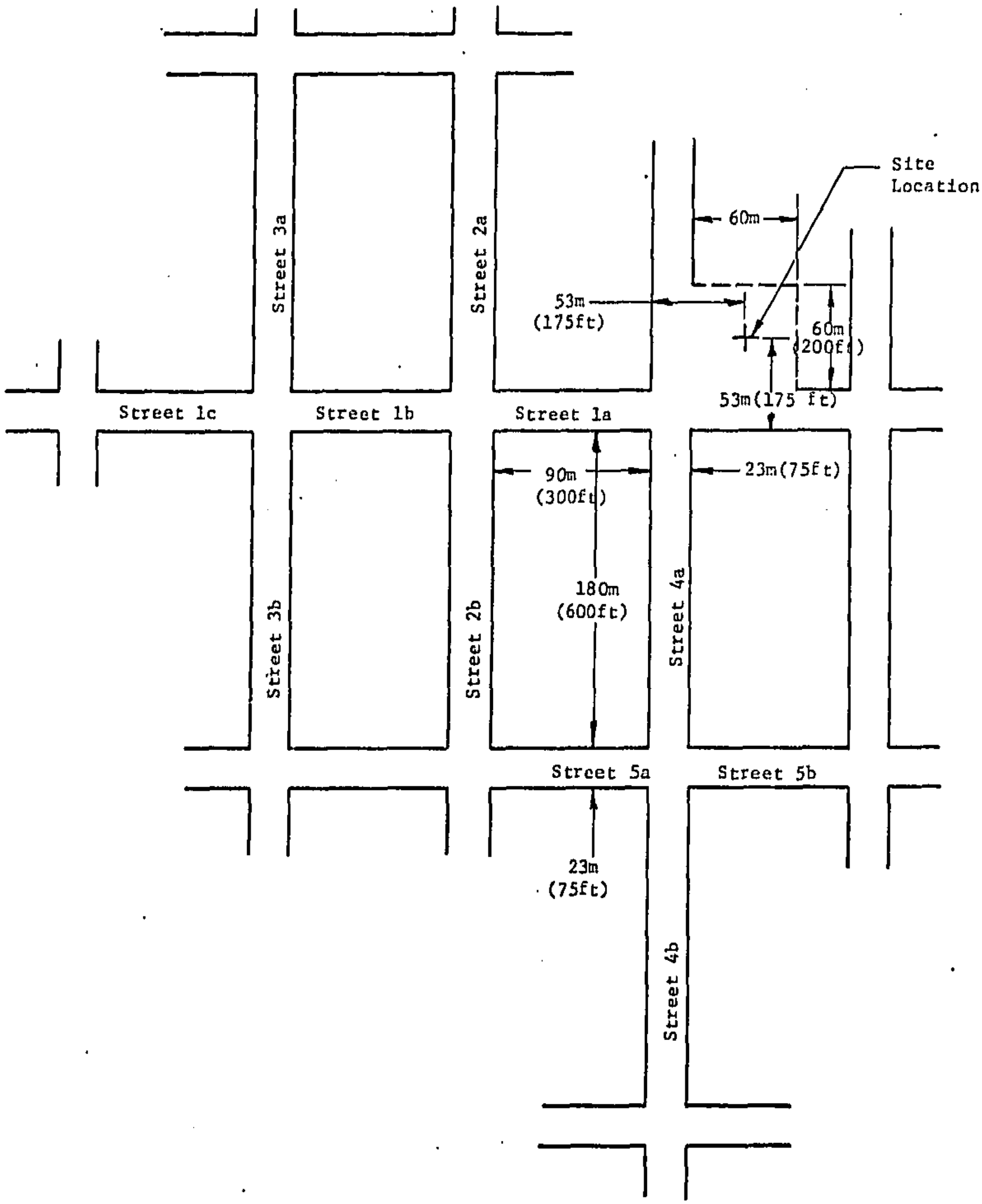

Figure 6 : Geometry and Nomenclature for Block Configuration Case II, Site B

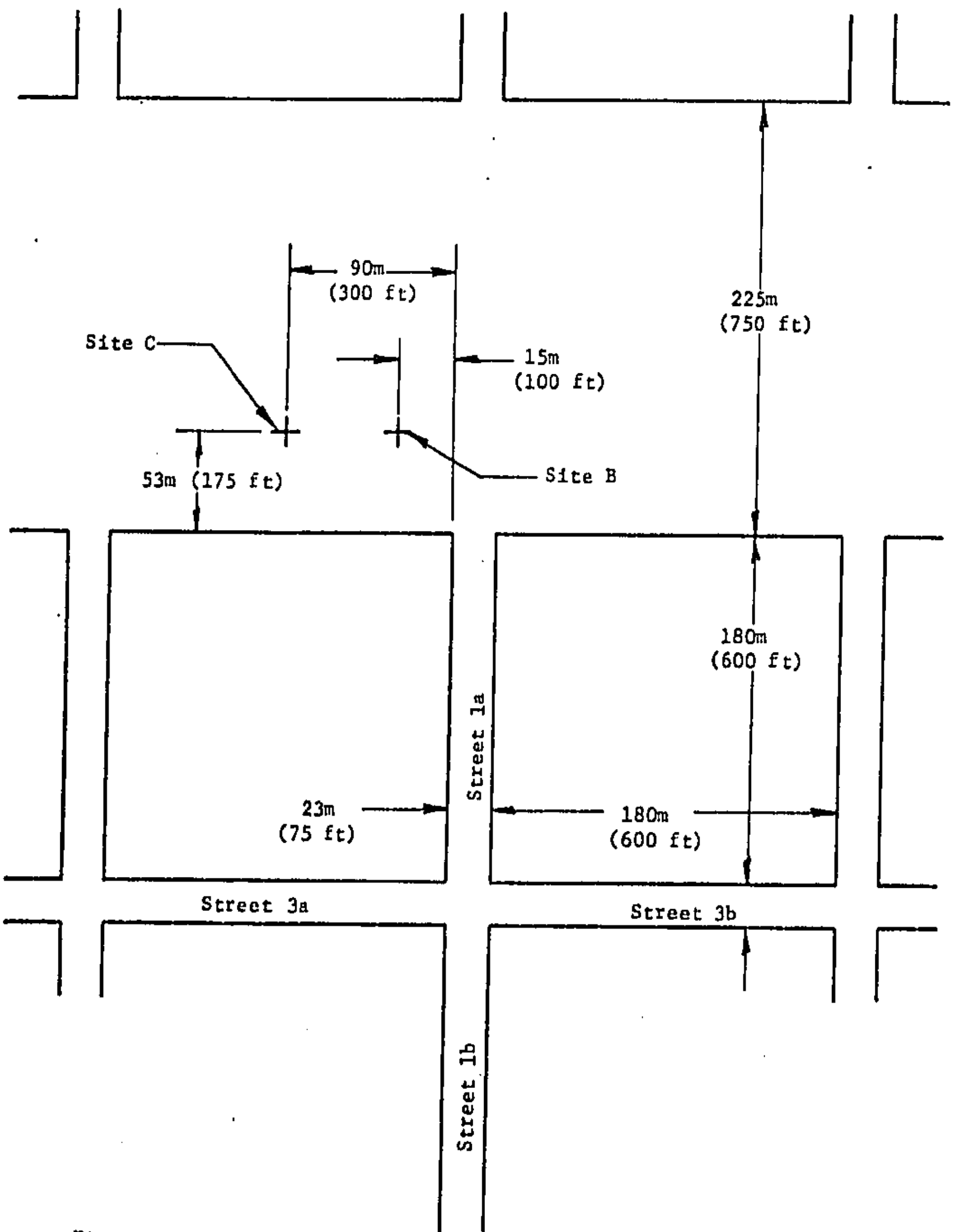

Figure 7: Assumed Geometry for Computed Attenuation Values for Block Configuration Case I, Sites B and C.

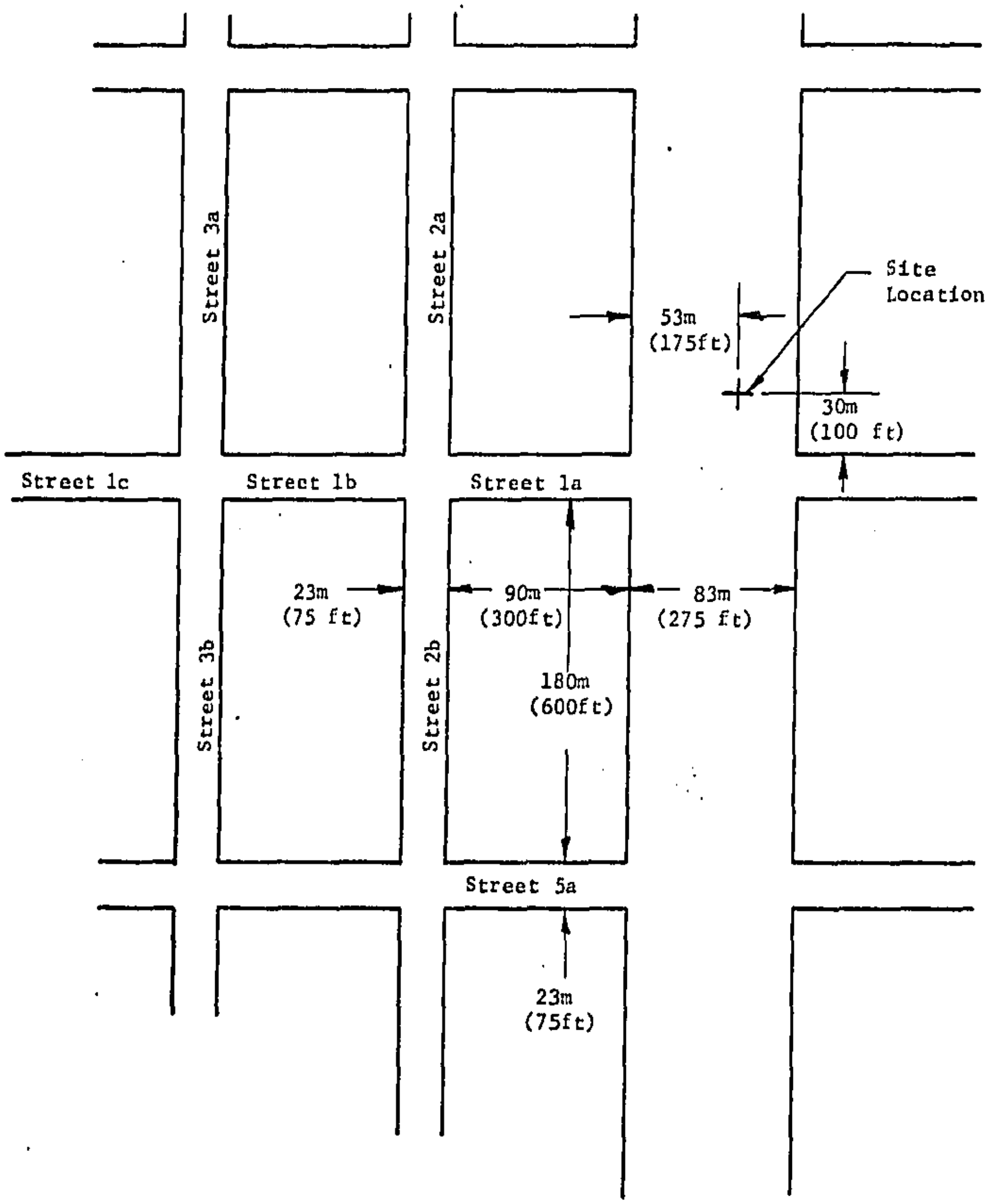

Figure 8: Assumed Geometry for Computed Attenuation Values for Block Configuration Case II, Site B

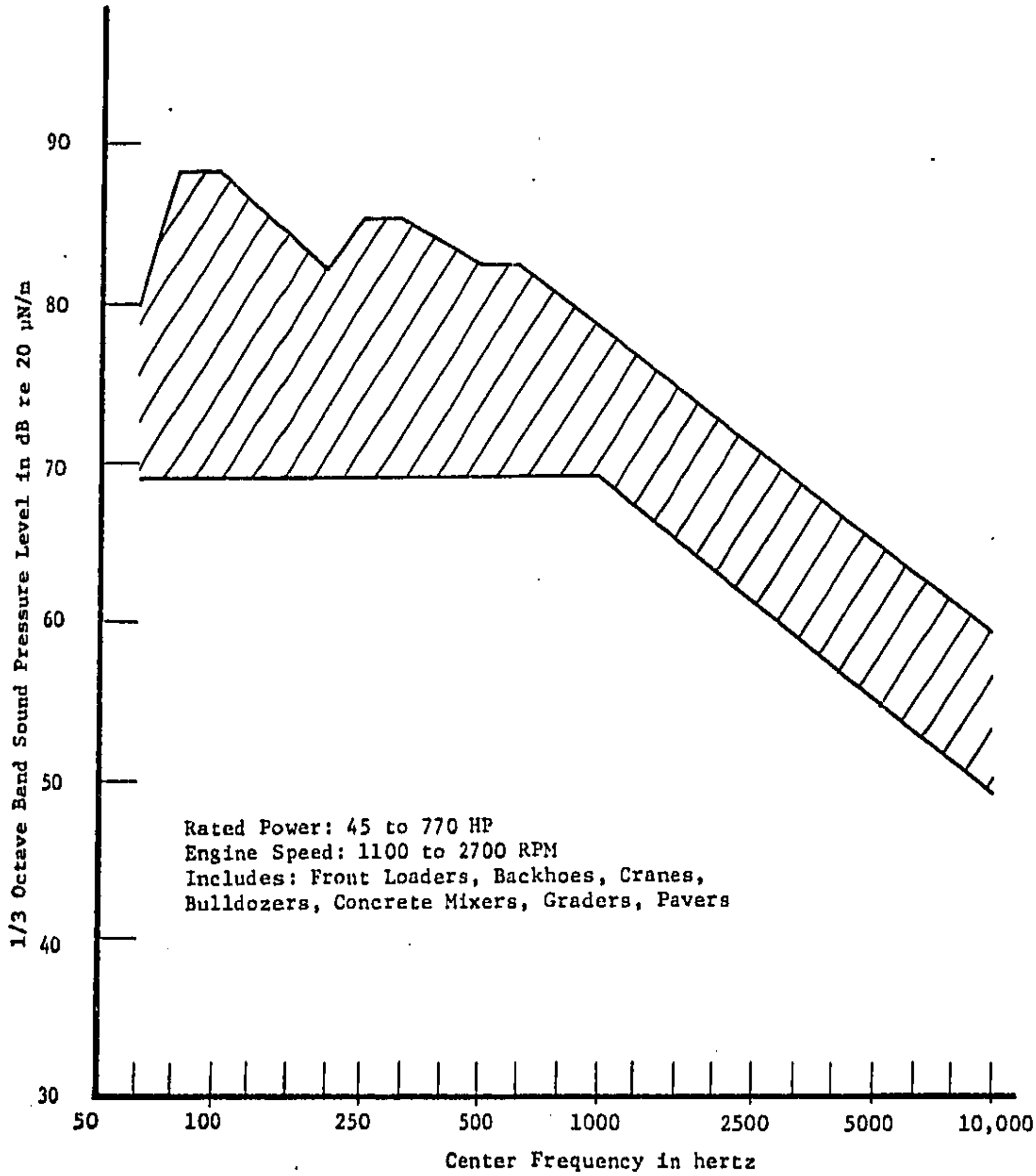

Figure 9: Envelope of Sound Pressure Levels from 23 Diesel-powered Items of Construction Equipment as Measured at 15m (50 ft)

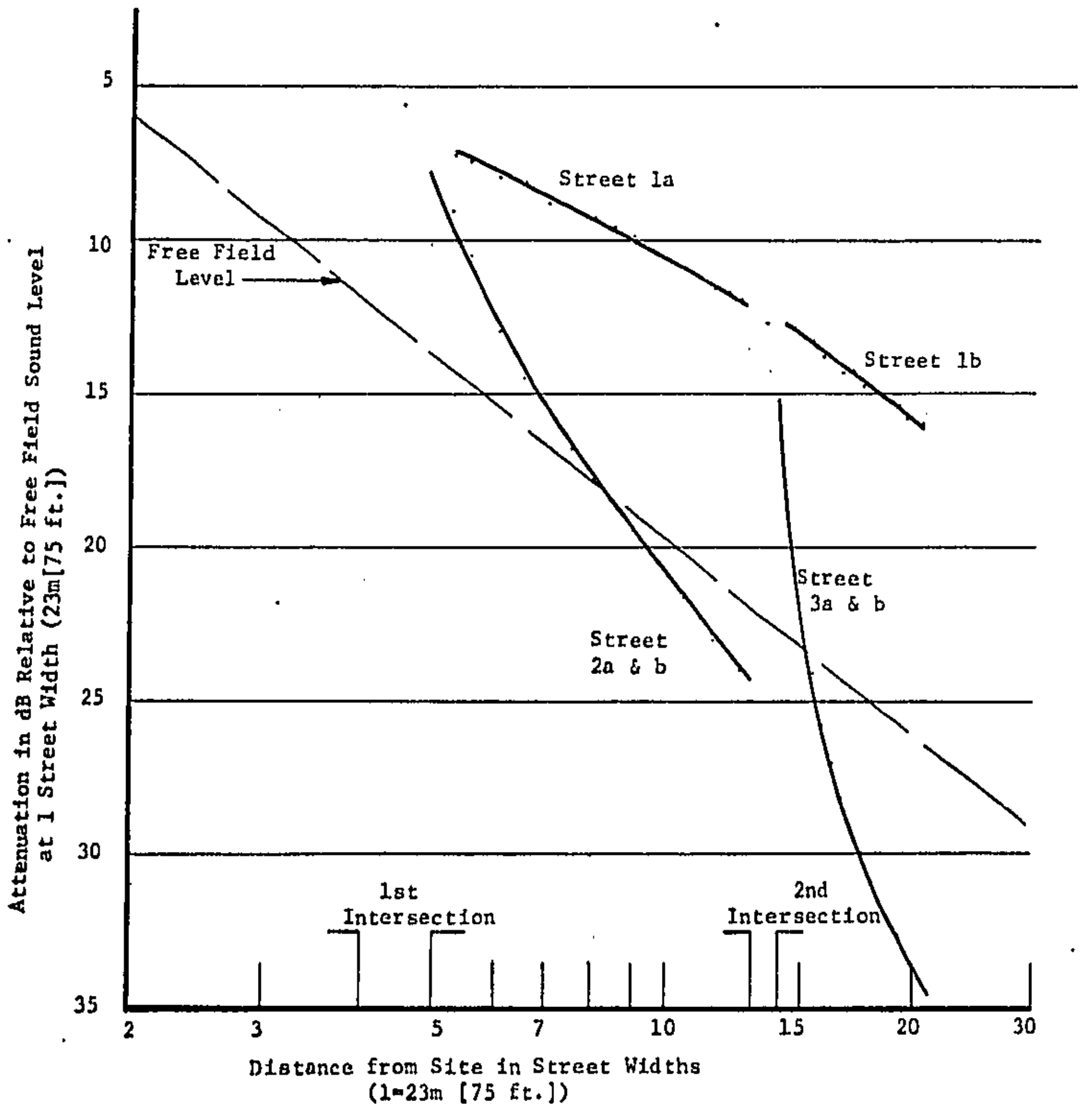

Figure 10: Attenuation as a Function of Distance for Case I, Site A

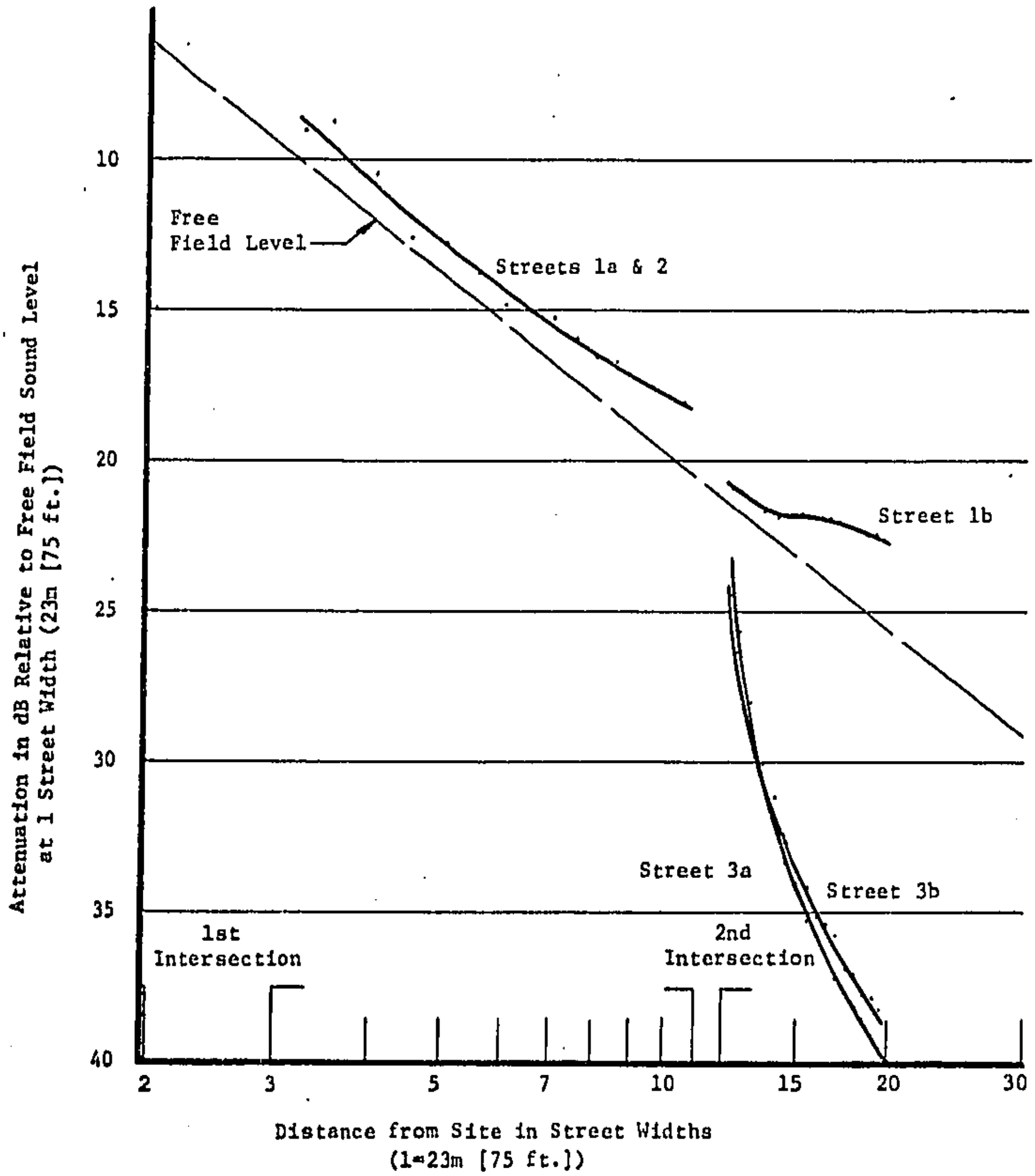

Figure 11: Attenuation as a Function of Distance for Case I, Site B

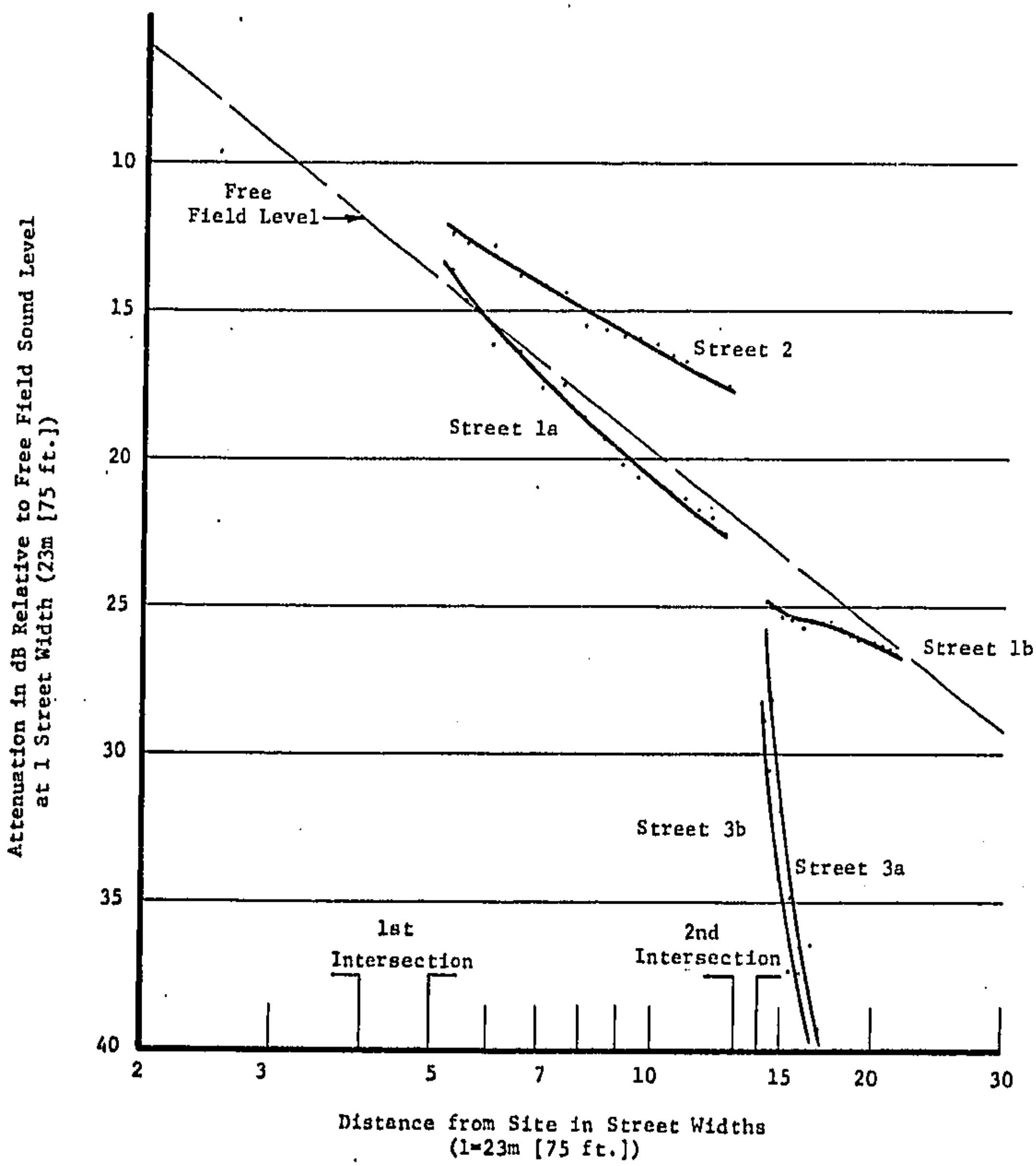

Figure 12: Attenuation as a Function at Distance for Case I, Site C.

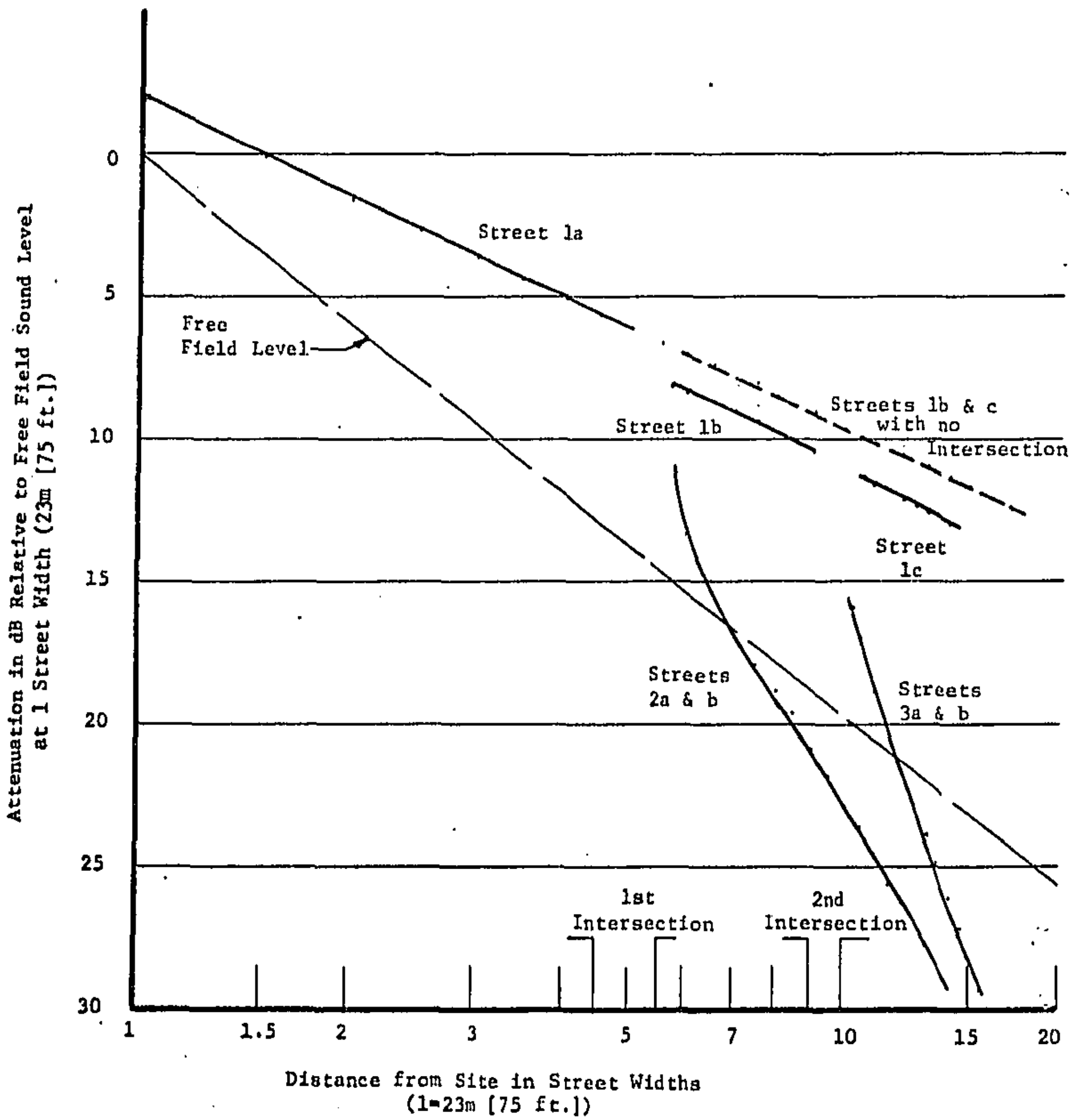

Figure 13: Attenuation as a Function of Distance for Case II, Site A, Streets 1, 2, and 3.

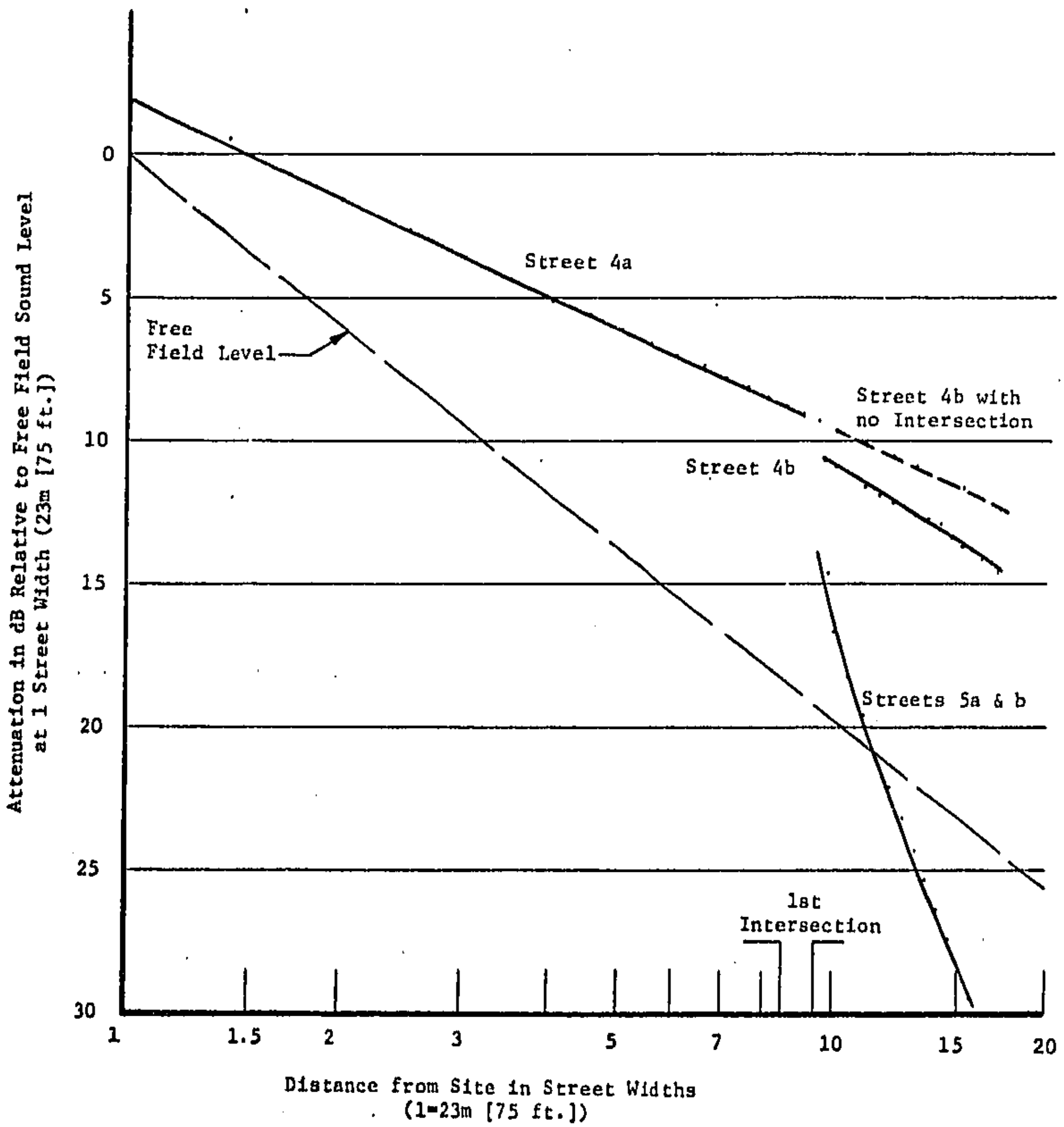

Figure 14: Attenuation as a Function of Distance for Case II, Site A, Streets 4 and 5.

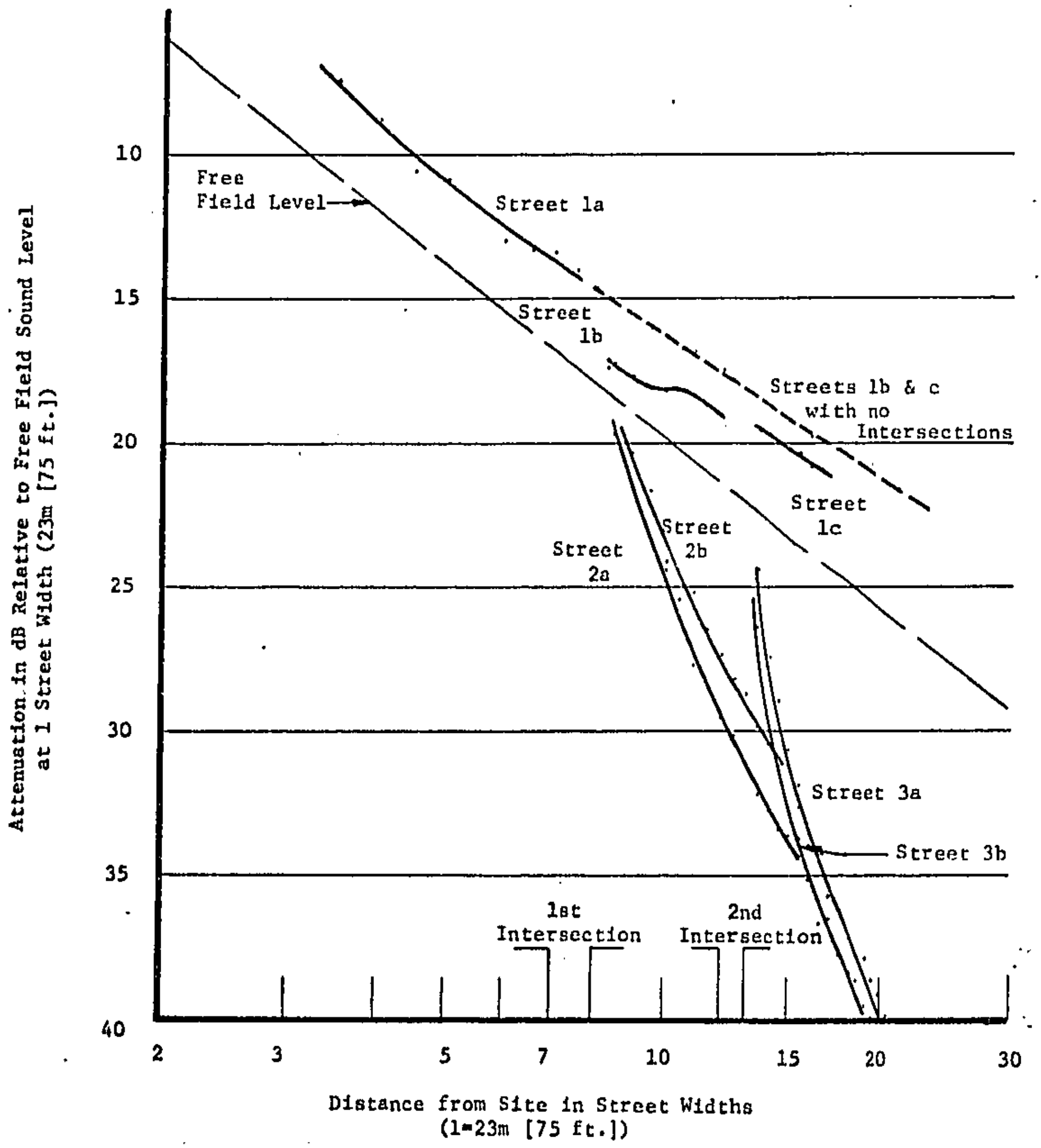

Figure 15: Attenuation as a Function of Distance for Case II, Site B, Streets 1, 2, and 3.

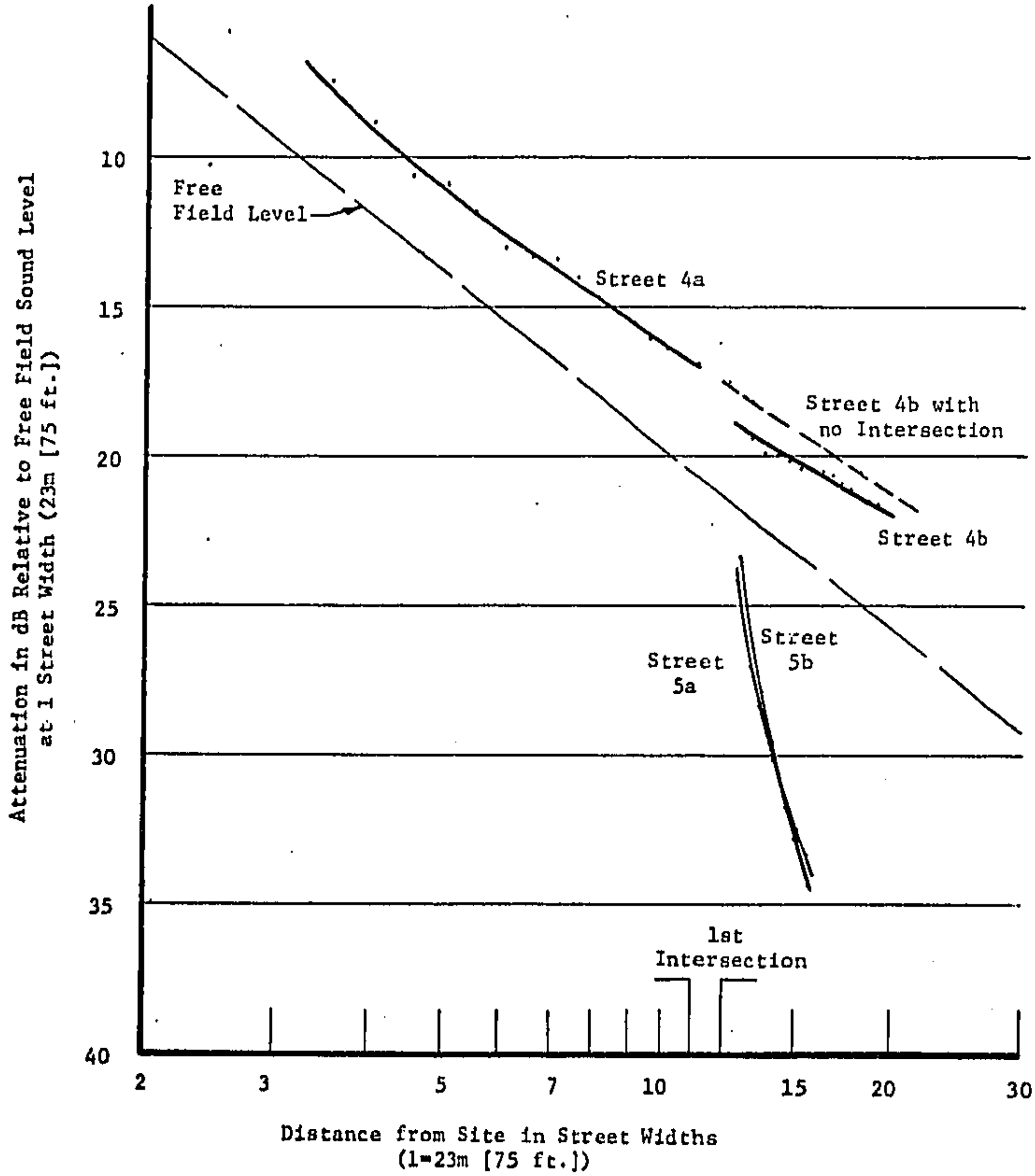

Figure 16: Attenuation as a Function of Distance for Case II, Site B Streets 4 and 5.

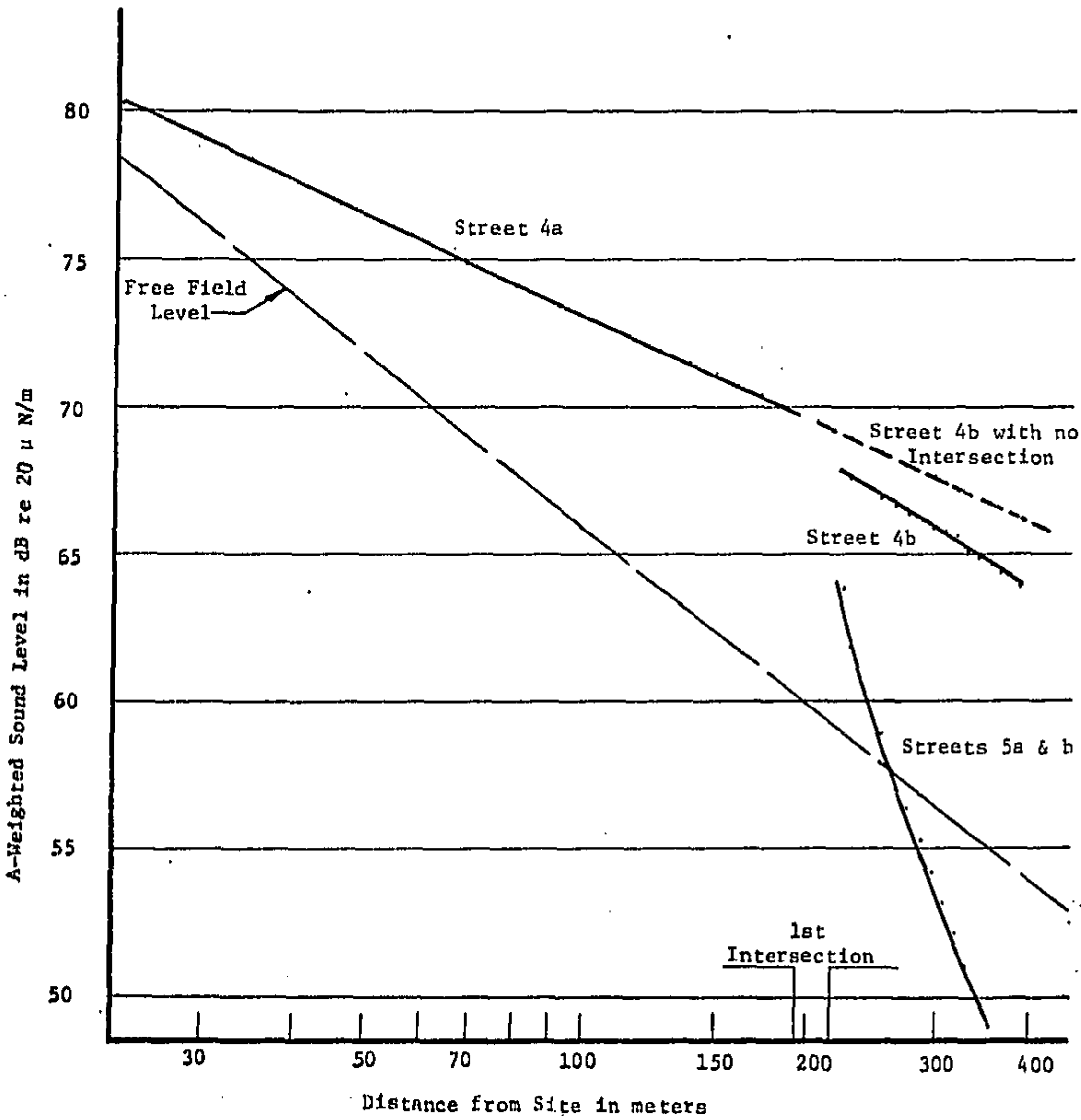

Figure 17: A-Weighted Sound Levels as a Function of Distance for Case II, Site A, Streets 4 and 5 for a Source Level of 82 dB at 15m (50 ft)

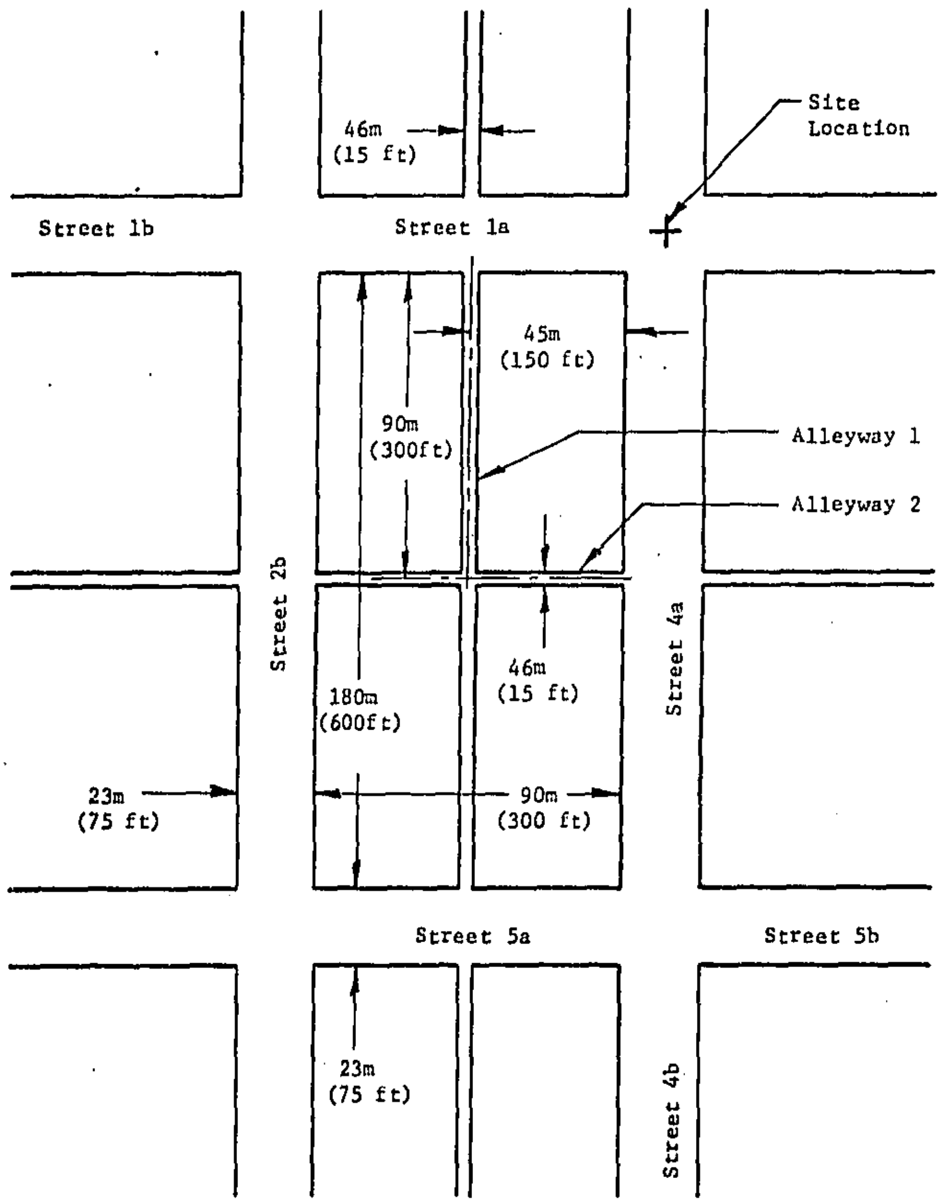

Figure 18: Geometry and Nomenclature for Assessment of Sound Propagation into Blocks Along Alleyways - Case II, Site A

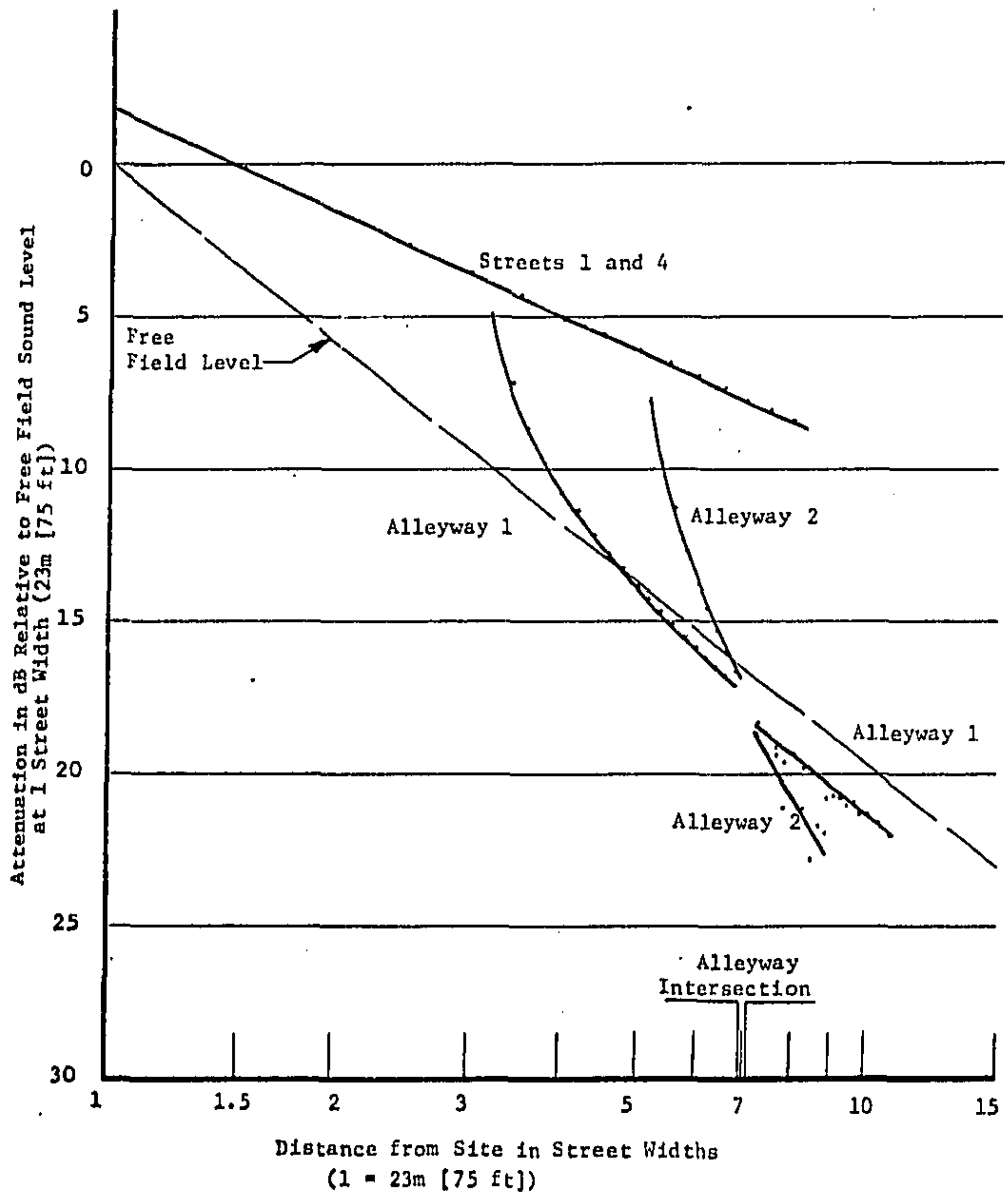

Figure 19: Attenuation as a Function of Distance for Case II, Site A, Alleyways 1 and 2 (strictly valid for only octave band sound pressure levels greater than 500 Hz.)

Table 1: Case I, Site A, Street 1 - Attenuation Relative to Free Field Sound Level At 1 Street Width (75 ft.) as a Function of Distance From the Site.

Street 1a		Street 1b	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
5.2	7.3	14.2	12.7
5.5	7.5	14.5	12.9
6.0	8.0	15.0	13.2
6.5	8.2	15.5	13.4
7.0	8.8	16.0	13.8
7.5	9.0	16.5	13.9
8.0	9.4	17.0	14.4
8.5	9.6	17.5	14.3
9.0	10.0	18.0	14.8
9.5	10.4	18.5	14.8
10.0	10.7	19.0	15.1
10.5	11.0	19.5	15.3
11.0	11.3	20.0	15.3
11.5	11.6	20.5	15.8
12.0	11.7	21.0	15.9
12.5	12.0	21.5	16.0

Table 2 : Case I, Site A, Streets 2 and 3 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into Side Street

Distance (Street Widths)	Streets 2a & b Attenuation (dB)	Streets 3a & b Attenuation (dB)
.25	9.1	18.0
.5	10.5	19.9
1.0	13.0	22.7
1.5	14.5	24.1
2.0	15.5	25.8
2.5	16.8	27.0
3.0	17.8	28.2
3.5	18.5	29.1
4.0	19.5	30.0
4.5	20.2	30.9
5.0	21.0	31.5
5.5	21.6	32.0
6.0	22.3	32.6
6.5	23.0	33.2
7.0	23.4	33.7
7.5	24.0	34.1

Table 3: Case I, Site B, Streets 1 and 2 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft) as a Function of Distance from the Site as Measured Along the Street

Street 1a & 2		Street 1b	
Distance (Street Widths	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
2.6	9.0	12.6	20.9
2.8	8.7	12.8	21.0
3.3	10.5	13.3	21.3
3.8	12.6	13.8	21.6
4.3	12.7	14.3	21.8
4.8	13.7	14.8	21.8
5.3	14.8	15.3	21.7
5.8	15.0	15.8	21.8
6.3	15.2	16.3	21.8
6.8	15.9	16.8	21.8
7.3	16.5	17.3	22.0
7.8	16.7	17.8	22.2
8.3	17.2	18.3	22.3
8.8	17.5	18.8	22.4
9.3	17.8	19.3	22.4
9.8	18.0	19.8	22.6

Table 4 : Case I, Site B, Street 3 – Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft) as a Function of Distance into the Side Street

Distance (Street Widths)	Street 3a Attenuation (dB)	Street 3b Attenuation (dB)
.25	23.8	24.5
.5	25.7	26.4
1.0	28.0	29.1
1.5	30.4	30.1
2.0	31.8	31.2
2.5	33.4	32.7
3.0	33.6	34.0
3.5	35.3	34.1
4.0	35.8	35.1
4.5	36.3	35.3
5.0	37.2	35.7
5.5	37.6	36.8
6.0	38.1	37.0
6.5	38.5	37.7
7.0	39.1	37.8
7.5	39.5	38.2

Table 5: Case I, Site C, Street 1 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance from the Site as Measured Along the Street

Street 1a		Street 1b	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
2.6	13.6	12.6	24.9
2.8	14.7	12.8	25.0
3.3	16.2	13.3	25.3
3.8	16.4	13.8	25.4
4.3	17.6	14.3	25.7
4.8	17.5	14.8	25.5
5.3	18.6	15.3	25.5
5.8	19.4	15.8	25.5
6.3	20.2	16.3	25.7
6.8	20.6	16.8	25.9
7.3	20.7	17.3	26.1
7.8	21.1	17.8	26.1
8.3	21.3	18.3	26.2
8.8	21.7	18.8	26.3
9.3	22.0	19.3	26.4
9.8	22.5	19.8	26.6

Table 6: Case I, Site C, Street 2 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance from the Site as Measured Along the Street

Street 2

Distance (Street Widths)	Attenuation (dB)
5.25	12.4
5.5	12.7
6.0	12.7
6.5	13.8
7.0	14.1
7.5	14.4
8.0	15.5
8.5	15.6
9.0	15.8
9.5	15.9
10.0	16.1
10.5	16.5
11.0	16.7
11.5	17.2
12.0	17.4
12.5	17.5

Table 7 : Case I, Site C, Street 3 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into the Side Street

Distance (Street Widths)	Street 3a Attenuation (dB)	Street 3b Attenuation (dB)
.25	26.1	28.8
.5	28.1	30.5
1.0	31.9	34.2
1.5	34.9	37.3
2.0	36.5	37.4
2.5	36.4	38.0
3.0	39.3	40.6
3.5	41.6	42.3
4.0	41.2	41.8
4.5	41.5	41.9
5.0	43.0	43.6
5.5	44.1	43.8
6.0	43.2	43.8
6.5	44.3	44.6
7.0	45.2	45.0
7.5	44.7	45.3

Table 8: Case II, Site A, Street 1 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance from the Site

Street 1a		Street 1b		Street 1c	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
.75	-2.8	5.7	8.2	10.7	11.3
1.0	-1.9	6.0	8.4	11.0	11.6
1.5	0.1	6.5	8.7	11.5	11.8
2.0	1.6	7.0	9.0	12.0	12.1
2.5	2.7	7.5	9.4	12.5	12.4
3.0	3.6	8.0	9.8	13.0	12.6
3.5	4.4	8.5	10.1	13.5	12.7
4.0	5.1	9.0	10.5	14.0	13.0
4.5	5.6				

Table 9: Case II, Site A, Streets 2 and 3 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into the Side Street

Streets 2a and b		Streets 3a and b	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
.3	11.2	.3	15.9
.5	13.4	.5	17.0
1.0	15.0	1.0	18.9
1.5	16.8	1.5	20.3
2.0	17.9	2.0	21.6
2.5	18.8	2.5	22.8
3.0	19.7	3.0	23.8
3.5	20.9	3.5	24.9
4.0	21.8	4.0	26.1
4.5	23.0	4.5	27.2
5.0	23.6	5.0	28.3
5.5	24.6	5.5	29.4
6.0	25.6	6.0	30.5
6.5	26.2	6.5	31.5
7.0	26.9	7.0	32.3
7.5	27.7	7.5	33.1

Table 10: Case II, Site A, Street 4 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance from the Site

Street 4a		Street 4b	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
.75	-2.8	9.7	10.7
1.0	-1.9	10.0	10.9
1.5	.1	10.5	11.2
2.0	1.6	11.0	11.6
2.5	2.7	11.5	11.9
3.0	3.6	12.0	12.1
3.5	4.4	12.5	12.3
4.0	5.1	13.0	12.6
4.5	5.6	13.5	12.7
5.0	6.1	14.0	12.9
5.5	6.6	14.5	13.4
6.0	7.0	15.0	13.6
6.5	7.4	15.5	13.8
7.0	7.8	16.0	14.1
7.5	8.1	16.5	14.2
		17.0	14.6

Table 11: Case II, Site A, Street 5 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into the Side Street

Streets 5a and b

Distance (Street Widths)	Attenuation (dB)
.3	14.7
.5	16.6
1.0	18.2
1.5	19.6
2.0	21.0
2.5	22.1
3.0	23.2
3.5	24.3
4.0	25.3

Table 12: Case II, Site B, Street 1 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance From the Site as Measured Along the Street

Street 1a		Street 1b		Street 1c	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
2.6	7.7	7.6	17.4	12.6	19.4
2.8	7.5	7.8	17.2	12.8	19.5
3.3	8.8	8.3	17.7	13.3	19.7
3.8	10.6	8.8	18.2	13.8	20.0
4.3	10.8	9.3	18.2	14.3	20.2
4.8	11.8	9.8	18.1	14.8	20.4
5.3	13.0	10.3	18.4	15.3	20.8
5.8	13.3	10.8	18.7	15.8	20.9

Table 13: Case II, Site B, Streets 2 and 3 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into the Side Street

Distance (Street Widths)	Street 2a Attenuation (dB)	Street 2b Attenuation (dB)	Street 3a Attenuation (dB)	Street 3b Attenuation (dB)
.3	19.1	17.4	22.2	24.0
.5	19.5	19.7	24.4	26.4
1.0	21.4	20.3	27.5	28.1
1.5	23.2	21.6	29.0	31.1
2.0	24.3	24.1	30.7	32.7
2.5	26.1	25.4	32.6	33.7
3.0	27.7	25.2	34.0	35.1
3.5	28.3	26.5	34.5	36.7
4.0	29.5	27.3	35.7	36.5
4.5	30.1	28.2	36.2	37.7
5.0	31.2	28.6	37.1	38.3
5.5	32.2	29.9	37.9	38.7
6.0	32.6	30.4	37.9	39.5
6.5	33.3	30.9	38.6	39.9
7.0	33.6	31.2	39.1	40.7
7.5	34.4	31.8	39.4	40.7

Table 14: Case II, Site B, Street 4 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance from the Site as Measured Along the Street

Street 4a		Street 4b	
Distance (Street Widths)	Attenuation (dB)	Distance (Street Widths)	Attenuation (dB)
2.6	7.7	11.6	18.9
2.8	7.5	11.8	19.0
3.3	8.8	12.3	19.3
3.8	10.6	12.8	19.8
4.3	10.8	13.3	19.9
4.8	11.8	13.8	20.1
5.3	13.0	14.3	20.3
5.8	13.3	14.8	20.4
6.3	13.4	15.3	20.5
6.8	14.0	15.8	20.6
7.3	14.7	16.3	20.9
7.8	15.1	16.8	21.1
8.3	15.5	17.3	21.4
8.8	16.0	17.8	21.5
9.3	16.4	18.3	21.6
9.8	16.7	18.8	21.9

Table 15: Case II, Site B, Street 5 - Attenuation Relative to Free Field Sound Level at 1 Street Width (75 ft.) as a Function of Distance into the Side Street

Distance (Street Widths)	Street 5a Attenuation (dB)	Street 5b Attenuation (dB)
.3	22.9	22.0
.5	24.1	23.4
1.0	27.0	26.0
1.5	27.9	28.3
2.0	29.5	30.1
2.5	31.3	31.7
3.0	32.7	32.5
3.5	33.3	34.4

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

An existing urban sound propagation model has been applied to the specific problem of estimating the propagation of noise from urban construction sites along street corridors. Discussion summarizes the development of the propagation model and computer programs used to estimate sound propagation. The propagation model has been applied to five different construction site orientations resulting from two city block configurations. For each of the site orientations, the estimated values of attenuation versus distance in the streets surrounding individual sites are presented. Assuming the sound level at the construction site is known, the procedure to be used to determine sound levels in the surrounding streets is also provided.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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