



AEROSPACE INFORMATION REPORT

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METHOD FOR CALCULATING THE ATTENUATION OF AIRCRAFT GROUND TO GROUND NOISE PROPAGATION DURING TAKEOFF AND LANDING

1. PURPOSE - The purpose of this information report is to provide a standard method for predicting the propagation of noise over open terrain from (a) an airplane on the ground to other locations on the ground and from (b) an airplane at low altitude, - i. e., where ground effects exist - to locations on the ground at distances which are great compared with the airplane altitude.
2. DEFINITION - This report provides extensive information on what has been called the "shadow effect," i. e., attenuation resulting from temperature and wind gradients near the ground. This effect is called "extra ground attenuation" because it is in addition to the inverse square attenuation and the extra air attenuation.
3. CALCULATING EXTRA GROUND ATTENUATION - Extra ground attenuation is a function of (a) temperature and wind gradients and (b) wind velocity. Information regarding the effect of temperature, wind gradients, and velocity on extra ground attenuation are presented in the appendix. For the purpose of this report the following conditions have been established as standard conditions for calculating extra ground attenuation:
 3. 1 A wind velocity of 10 mph. The wind velocity averaged for about 60 airports in the United States has been found to be about 10 mph.

The peak noise from airplanes during take-off occurs at an angle of about 45 deg from the exhaust wake, which is in the downwind region. The extra ground attenuation at this angle is less for a 10-mph headwind than for (a) the no-wind condition with a thermal gradient or (b) a tail wind. In the downwind direction the extra ground attenuation is caused by scattering due to turbulence. For variations in wind velocity from 5 to 15 mph, the effects in the downwind direction are small.

Zero wind velocity has been selected as the standard velocity for airplane take-off tests because take-off with zero wind is the most difficult and take-off with zero wind is required. For the calculation of extra ground attenuation a different philosophy applies and the 10-mph wind velocity is selected as standard because it approximates a 5- to 15-mph condition, which exists most of the time. See wind velocity curves in Appendix 1, Figures 4 to 13.

3. 2 The thermal gradient for an average day is used. Thermal gradients which contribute to extra ground attenuation normally exist during the daylight hours only. However, the thermal gradient is less important than wind gradients.

3. 3 The source and receiver are assumed to be at a height of 6 ft.

3. 4 A ground roughness parameter of 5 cm is used. See Appendix 2. This roughness parameter determines the wind gradient close to the ground. See reference 1, Table 23, page 233; and reference 2, page 2.

The geometry of the acoustic shadow boundary is that shown in Figure 1.

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4. EXTRA GROUND ATTENUATION WITH THE AIRPLANE ON THE GROUND - The distance from the source to the shadow boundary in the upwind direction is about 200 ft. In this direction the sound level decreases with distance as shown in Figure 2a. These curves are based on an analysis of the data given in references 2 through 6, and from the theoretical studies in references 7 and 8. Similar curves for other directions leading into the shadow are shown in Figures 2b through 2f.

For the downwind sector (see Figure 1) the corresponding extra ground attenuation is shown in the 0 to 2 deg angle of elevation curves in Figure 4.

5. EXTRA GROUND ATTENUATION WITH AIRPLANE NEAR GROUND - For the purpose of calculating the attenuation of noise propagating from an airplane at low altitude, Figure 4 is included. These data are presented for varying angles of elevation from the receiver to the source and are based on an analysis of the experimental results given mainly in reference 6.

It should be pointed out that the curves do not include "ground absorption" which has been observed to be present particularly in the frequency band 300 - 600 cps. Theoretical curves showing this effect are given in reference 2, and experimental data are given in references 2, 4, and 5. However, since this effect depends on the acoustical impedance of the ground, it is not included in this report at this time. Therefore, in the band 300 - 600 cps, the attenuation in Figure 4 may be approximately 5 db too small for distances above 1000 feet unless the ground is a perfectly reflecting surface such as concrete.

The shape of the attenuation curves shown in Figure 4 are understood to be the result of scattering in the turbulent boundary layer near the ground. The thickness of this layer is of the order of 100 ft (see reference 1). The main effect on the attenuation of sound from an elevated source is considered to be due to that portion of the path that is located within the turbulent boundary layer as shown schematically in Figure 3.

It should be emphasized that the curves presented here are representative averages of the present available data and are subject to revision when further information becomes available.

PREPARED BY SAE COMMITTEE A-21, AIRCRAFT EXTERIOR NOISE MEASUREMENTS

REFERENCES

1. O. G. Sutton, Micrometeorology, McGraw Hill, 1953.
2. Uno Ingard, The Physics of Outdoor Sound, Proc. of the 4th National Noise Abatement Symposium Vol. 4, 1953.
3. Oleson and U. Ingard, Field measurement of sound propagation over ground. NASA Report N63-13720.
4. Francis M. Wiener and David N. Keast, Experimental study of sound over ground. Jour. Acoust. Soc. 31,724, 1959.
5. Building Research Station Note No. B 249, Measurement of the horizontal propagation of noise from a jet engine source at Radlett, July 1959 to August 1960.
6. M. D. Burkhard, H. B. Karplus, H. J. Sabine, Sound propagation near the earth's surface as influenced by weather conditions. WADC Technical Report 57-353 part II. Dec. 1960.
7. H. J. Sabine, Sound propagation near the earth's surface as influenced by weather conditions. WADC Technical Report 57-353.
8. David C. Pridmore-Brown and Uno Ingard, Tentative method for calculation of the sound field about a source over ground considering diffraction and scattering into shadow zones. NACA technical note 3779, Sept. 1956.
9. An extensive set of references to earlier studies can be found in Uno Ingard, A review of the influence of meteorological conditions on sound propagation, Jour. Acous. Soc. 25, 405, 1953.
10. P. H. Parkin and W. E. Scholes, The horizontal propagation of sound from a jet engine close to the ground at Hatfield. Journal of Sound and Vibration (1965) 2, 353.

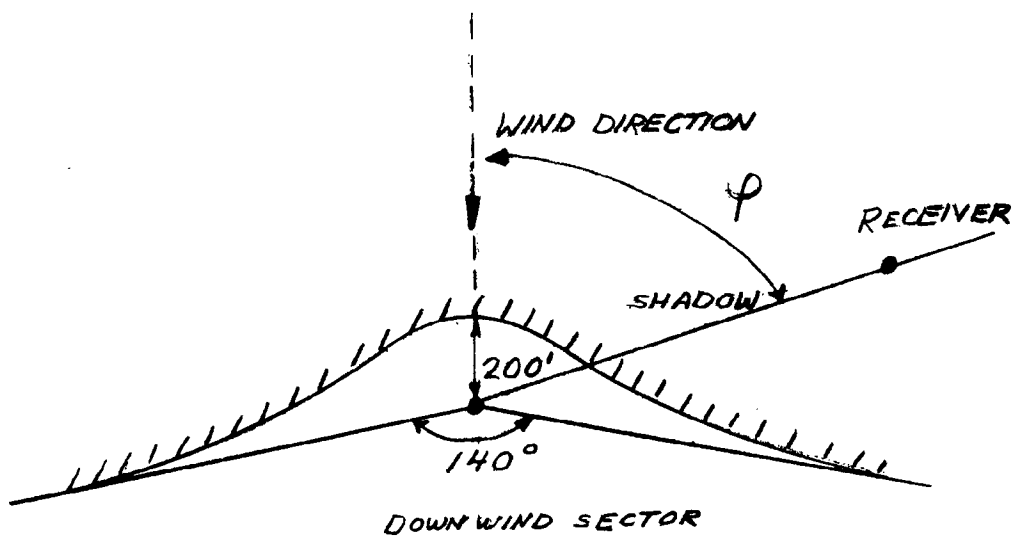
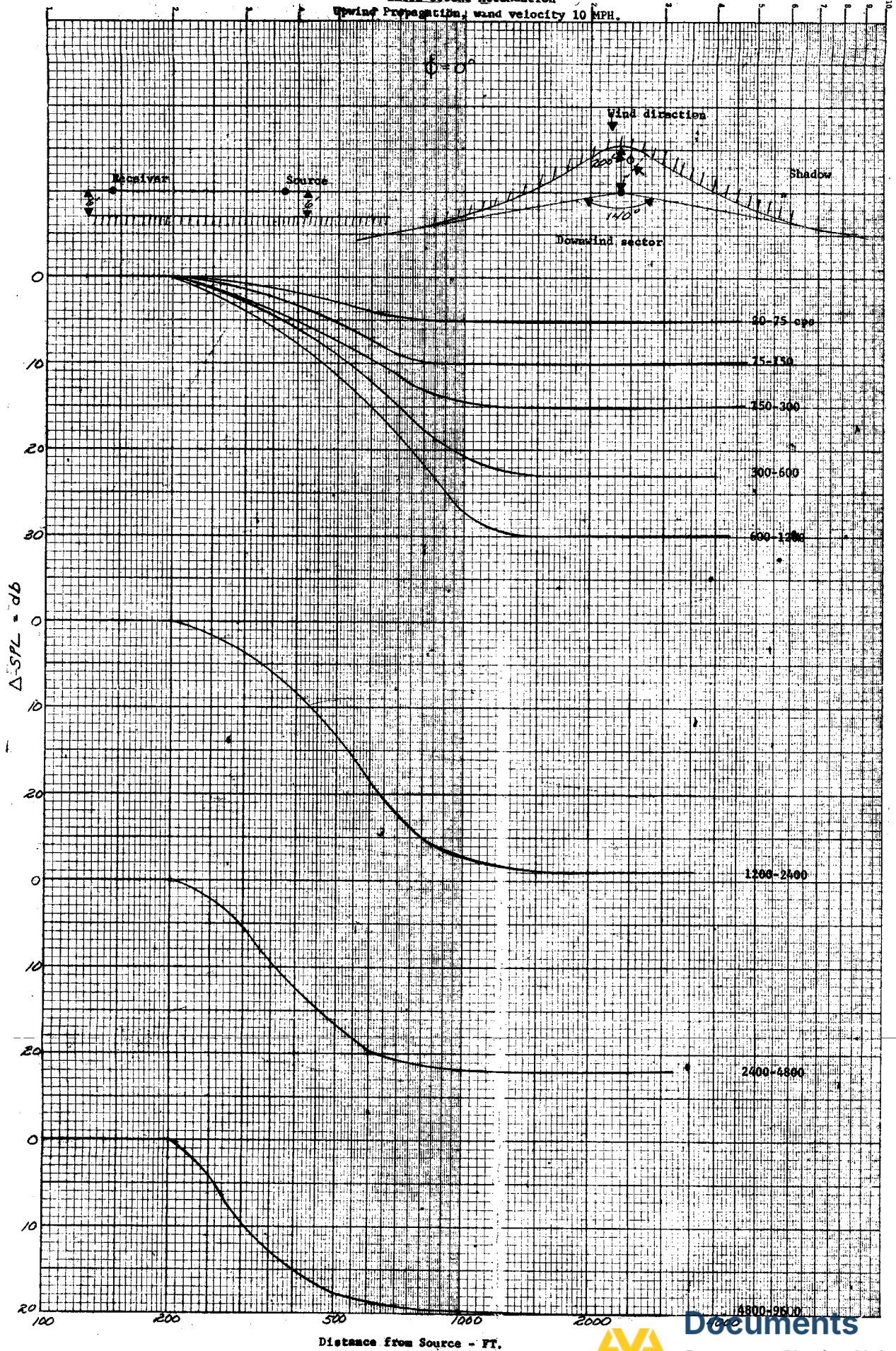


FIGURE 1

Extra Ground Attenuation
Upwind Propagation, wind velocity 10 MPH.



Extra Ground Attenuation
Upwind Propagation, wind velocity 10 MPH.

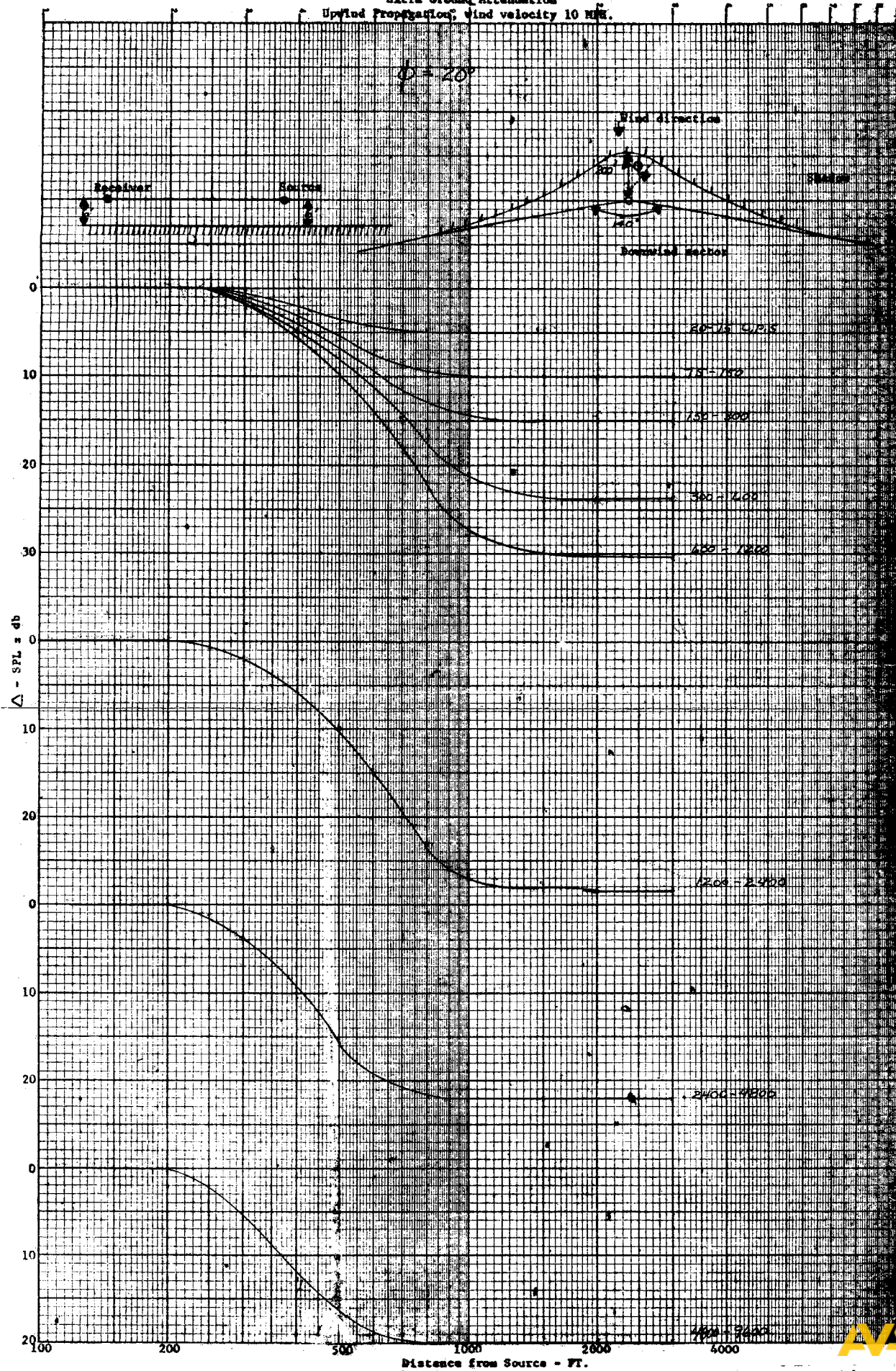
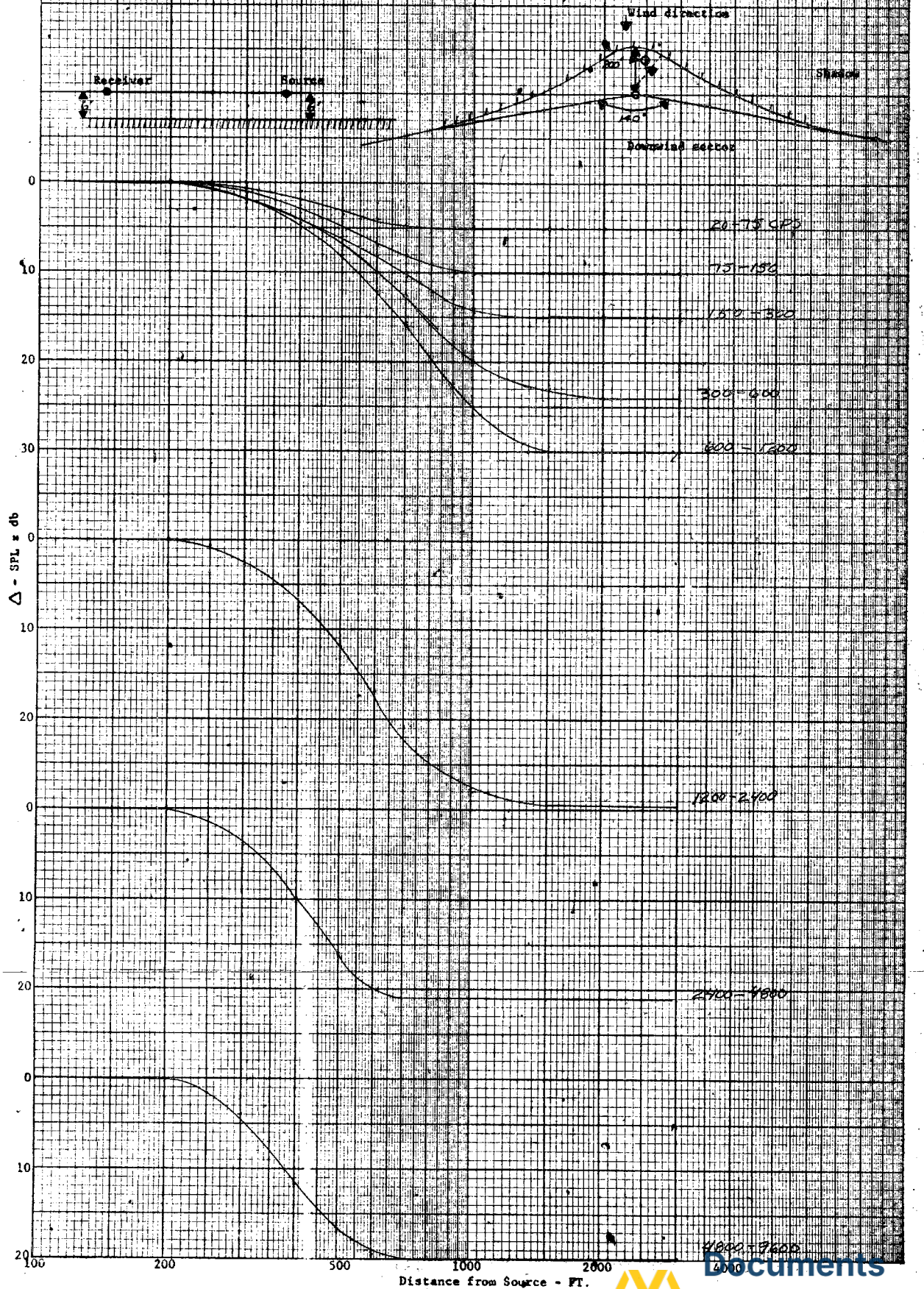


FIGURE 2-b



Extra Ground Attenuation
Upwind Propagation; wind velocity 10 MPH.

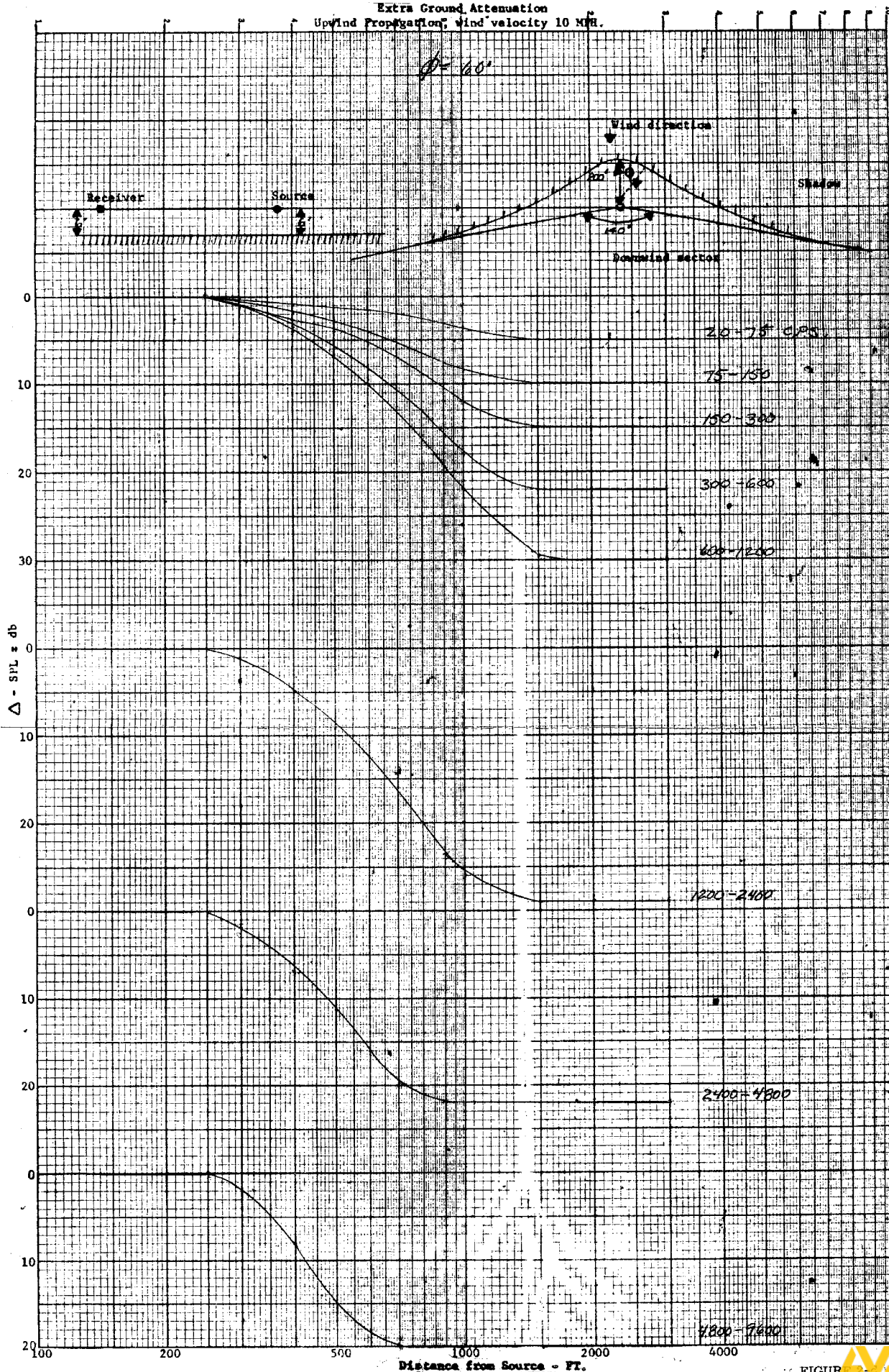
$\phi = 40^\circ$



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Extra Ground Attenuation
Upwind Propagation, wind velocity 10 MPH.



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FIGURE 2

Extra Ground Attenuation
Upwind Propagation; wind velocity 10 MPH.

