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WIND SHEAR MODELING FOR AIRCRAFT HAZARD DEFINITION

Walter Frost
Dennis W. Camp
S.T. Wang

February 1978
FINAL REPORT

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16. Abstract

Wind shear at low altitudes in the terminal area has been identified as hazardous to aircraft operations. Mathematical models of wind profiles have been developed for use in fast time and manned flight simulation studies aimed at defining and eliminating these wind shear hazards. A set of wind profiles and associated wind shear characteristics for stable and neutral boundary layers, thunderstorms, and frontal winds potentially encounterable by aircraft in the terminal area are given. Wind shear is defined as significant changes in wind speed and/or direction up to 500 m above the ground that may adversely affect the approach, landing, or takeoff of an aircraft.

Engineering models of wind shear for direct hazard analysis are presented in mathematical formulae, graphs, tables, and computer lookup routines. The wind profile data utilized to establish the models is described as to location, how obtained, time of observation and number of data points up to 500 m. These models provide the three components of wind speed in two-dimensional vertical planes, i.e., as functions of the vertical and horizontal coordinates.

Statistical data is provided, where available, as to the risk of exceeding the wind shear environment predicted by the models.

Recommendations, engineering interpretations and guidelines for use of the data are given and the range of applicability of the wind shear models are described.

Results of the study are summarized and conclusions and recommendations concerning future efforts which should be pursued by Government and industry are given. The data deficiency and the associated weaknesses and strengths of the models are also described.

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PREFACE

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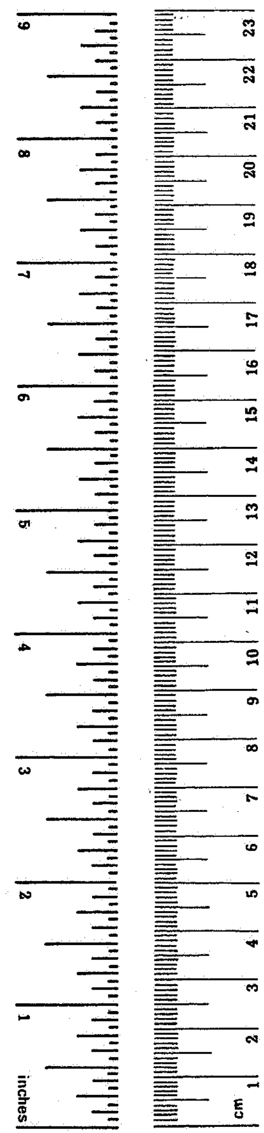
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

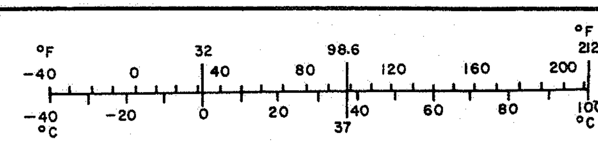
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SECTION 1.0

INTRODUCTION

1.1 Background

Wind shear, particularly at the lower altitudes in the terminal area, has been identified as being hazardous to aircraft operations. Accurate and reliable wind profiles are required for use in fast time and manned flight simulation studies aimed at fully defining and understanding the wind shear hazard. This report describes wind speed profiles developed for the above simulation to improve the safety and reliability of operations in the terminal area. A comprehensive set of wind profiles and associated wind shear characteristics which encompass many of the wind shear environments potentially encounterable by aircraft in the terminal area have been modelled, subject to the data available. For the purpose of this effort, wind shear is defined as significant changes in wind speed and/or direction up to 500 m above the ground which may adversely affect the approach, landing, or takeoff of an aircraft. The wind shear is mathematically modelled and the mathematical scenarios (environment) are presented in a format for direct application to wind shear hazard/flight simulation studies.

1.2 General Description of Wind Shear Models

A survey of existing wind shear data and mathematical models which are comprehensive, of sufficient spatial extent, and detailed enough for the development of mathematical models of wind shear is reported in Reference [1-1]. This reference reviews the state of the art and describes the scale and duration of frontal wind shear, neutral and stable boundary layer wind shear, and thunderstorm wind shear. The physics of these atmospheric phenomena with which significant wind shear is associated is also outlined in this reference and is not described in the present report. Selected data sets reported in the literature and described in Reference [1-1] have been chosen for the three wind shear conditions considered, i.e., 1) thunderstorm wind shear, 2) neutral and stable boundary layer wind shear and 3) frontal wind shear. In all three cases, the most comprehensive set of wind shear data reported in the literature have been discretized to a grid system and a computer program lookup with interpolation capabilities developed. The spatial variation of wind speed, both horizontally and vertically, is obtained from the programs when called by a main simulation program. The location of data measurement, how the data were obtained, the time of observation and the extent of the data up to 500 m are outlined for each of the wind shear conditions considered. From these data sets, a description of steady state wind which, in the thunderstorm and frontal cases, is effectively a quasi-steady state wind having a 10 sec averaging period are described. For the stable and neutral boundary layer case, the wind speeds are mean values which are defined as a 10 min average or greater. For the neutral and stable boundary layer, spatial dependence of the wind only in the vertical direction, z, is considered and the wind field in these cases is assumed homogeneous in horizontal extent. For the thunderstorm and frontal wind fields, both vertical, z, and horizontal, x, spatial dependence is considered. The data available, however, represents wind fields in a vertical plane sliced through the storm and spatial variation in the direction lateral to the motion of the storm is not considered. All three velocity components, that is, longitudinal velocity, W_x, lateral velocity, W_y, and vertical velocity, W_z, are defined at each point in the vertical spatial plane, however.

Since the high frequency component of the variation in the wind has been averaged out of the data sets used to define the mathematical form of the wind shear models, turbulence simulation techniques are provided from which a turbulent fluctuation can be generated and superimposed upon the quasi-steady state wind fields. For the thunderstorm and frontal models, the frequency content of the turbulent simulation must contain all fluctuations greater than 0.1 Hz. For the neutral and stable boundary layer the turbulence model must contain fluctuations of all frequencies.

Statistical models which will allow estimates of the probability of a given shear magnitude and the frequency of occurrence are developed to the extent current data permits. A statistical description of the wind fields are required to establish meaningful magnitudes of wind shear to assure that the values used in flight hazard studies are realistic and might actually be encountered in the real world. Statistical data, however, is very limited in this regard and it was necessary in most cases to establish only crude estimates of the probability of wind shear and the risk of exceeding a prescribed value.

1.3 Organization

The mathematical models of wind speed developed for thunderstorms, stable and neutral boundary layers, and the synoptic frontal storms are reported individually in Sections 2, 3 and 4, respectively. Each section describes the nature of the data set used to develop the table lookup programs and the theoretical turbulent simulation models recommended for use with the quasi-steady winds. Statistical models are also described and estimates of probabilities and risk of exceedance given. In the appendix, tables of the wind fields for easy engineering application are given. Also, numerous illustrative plots of typical wind speed profiles encountered along conventional flight paths are provided for visualization of the type and magnitude of wind shear potentially encounterable in the atmospheric conditions considered. Finally, a careful listing of the computer code and the associated data set are described. The computer programs are given in the form of subroutines which can be immediately coupled with a fast time computer program for calculating flight through wind shear hazards or for direct application to flight simulation studies. This material has been placed in the appendices because of its bulkiness and because, although it directly pertains to the engineering application of this report, it is not immediately relevant to the text of each section. However, the appendices have been numbered corresponding to the section of the report to which they refer. Appendix 1 contains the nomenclature while Appendices 2, 3 and 4 contain the tables, illustrations and computer code for the respectively numbered sections. Finally, each section contains recommendations and guidelines for engineering applications. The range of applicability, engineering interpretation, and examples of how to use the data are given.

The report concludes with a summary section which summarizes the results of the effort, presents conclusions, and provides recommendations concerning future efforts. A discussion of data deficiencies and the associated weaknesses and strengths of the model are also described in the summary section.

1.4 References

1-1. Frost, Walter, and D. W. Camp. "Wind Shear Modeling for Aircraft Hazard Definition," Interim Report No. FAA-RD-77-36, March 1977.

SECTION 2.0

THUNDERSTORM WIND SHEAR

A model of wind shear associated with thunderstorms has been developed from the data of Goff [2-1]. These data consist of measurements of longitudinal, lateral and vertical wind speeds at various levels of a 500 m tower. Although the data are measured along a vertical line in the atmosphere, they are projected horizontally to form a vertical plane using the concept of frozen turbulence or Taylor's hypothesis. Thus, the wind shear phenomena associated with thunderstorm models can be described as a two-dimension, spatial wind field.

The data of Goff [2-1], after careful review (see Reference [2-2]), were selected as being the best data available to construct a quantitative model of thunderstorm wind shear that provides both vertical and horizontal wind shear values. As noted, the model is restricted to two-dimensional space. The extensive survey reported in Reference [2-2] indicates that there are no three-dimensional data sets available nor any theoretical models associated with thunderstorms which would allow a three-dimensional simulation to be carried out. Therefore, it was necessary to restrict the simulation of thunderstorm wind shear to two-dimensional wind fields. The data, however, do include all three velocity components of the wind vector in the plane swept out by the 500 m tower as the storm passes.

2.1 Data Source

Thunderstorm wind shear data are presented in the form of longitudinal (W_x), lateral (W_y) and vertical (W_z) wind speed components in a vertical plane for 20 thunderstorm cases. Data for these 20 storms were measured during the months of May through June over the period of 1971 through 1973 with the WKY-TV/NSSL 481 m meteorological tower, Norman, Oklahoma. Time histories of the wind speed are converted to horizontal spatial distributions using Taylor's hypothesis (i.e., x = Wt). Ten second averaged values of wind speed components are provided in the form of isotach maps for W_x, W_y and W_z, respectively. These data were converted to a 41 x 11 point grid system as illustrated in Figure 2-1. The data for the 20 thunderstorm cases having been discretized on the grid system were stored on magnetic tape and a computer lookup routine developed for interpolating the W_x, W_y and W_z wind speeds for any location within the x-z plane. Tabulated data for W_x, W_y and W_z on the 41 x 11 point grid system are given in Appendix 2A; a pictorial description of the wind speed profiles and streamline patterns are given in Appendix 2B, and a computer program which stores the data on disks and carries out the table lookup with the option of superimposing turbulence is described in Appendix 2C.

The 20 thunderstorm cases for the purpose of this report are assigned numbers 1 through 20 which correspond to Goff's identification symbols A through T. All tabulated and illustrated data in the appendix contain both the numerical and the alphabetical identification.

2.2 Data Processing

For each thunderstorm, a 10 min record was taken and the data were averaged over 10 sec intervals throughout the 10 mins. These data were then fitted to a regular array of a 60 x 10 grid by Goff. Although the actual measurements were not uniformly spaced, the data as presented for public distribution were uniformly spaced on the 60 x 10 grid. Each 10 min record consists of 60 10 sec averaged data sets representing a cross section through the storm. Streamline patterns as well as isotach maps of W_x, W_y and W_z were also drawn from the data and are given in Reference [2-1].

The data presented in Reference [2-1] were evenly spaced over 10 50 m intervals in the z-direction. Values assigned to each interval were determined by linear interpolation from seven levels of measurements for the 1971, 1972 data and from only three levels of measurement for the 1973 and 1974 data. For the x-direction, 60 intervals were utilized where a Galilean transformation from time to space was utilized. The horizontal extent of each cross-section is therefore a variable and is equal to the frontal speed of the thunderstorm times the 10 min averaging period.

The coordinate system utilized in Reference [2-1] and also in this report defines the x-direction as being measured positively in the direction of frontal motion and the y-direction as being measured perpendicular to the

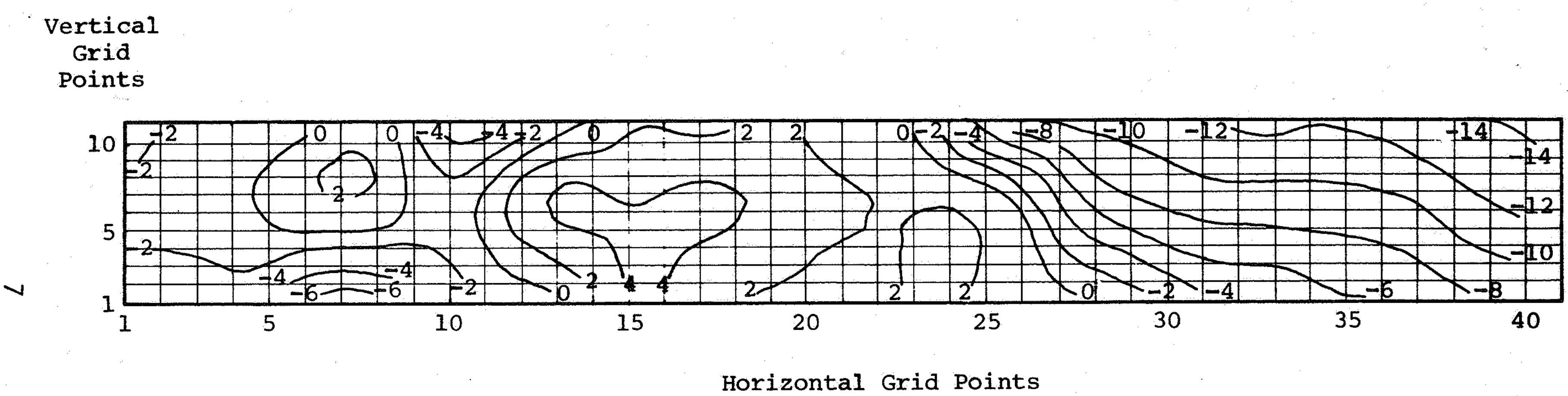


Figure 2-1 Grid System Superimposed on Typical Thunderstorm Wind Speed Contour Maps

frontal axis utilizing the right-hand rule, i.e., positive W_y is measured into the plane of the paper. The W_x components of the wind speed are positive in the direction of frontal motion, i.e., positive from left to right on the contour maps and the vertical wind speed, W_z, is positive in the upward direction.

The data presented by Goff [2-1] are the longitudinal wind speed, W_x, relative to the motion of the storm. In this report, however, the data are generally presented relative to the fixed frame of reference attached to the ground.

In view of the 10 sec averaging period utilized to reduce the data, all fluctuations in wind speed of frequency higher than 0.1 Hz have been filtered out of the data. Thus, the data contain variations in wind speed having frequencies of 0.1 Hz or less. These low frequencies are expected to be those to which aircraft motion is most sensitive. However, to assure correct simulation where high frequency wind components are significant, it is recommended that a turbulent fluctuation be superimposed upon the quasi-steady wind fields. Section 2.4 discusses and recommends a turbulence model for use with the thunderstorm gust front data.

The following section, Section 2.3, describes the quasi-steady wind speed profile grid system and presents working data for wind shear hazard/flight simulation studies. The wind speed is referred to as quasi-steady in view of the fact that it is averaged over 10 sec time intervals and thus contains departures from the mean wind speed which is generally averaged over a 10 min period or greater.

2.3 Quasi-Steady Wind Speed Profile Grid System

The wind fields of Goff [2-1] were fit to a 41 x 11 point grid system. The grid system as illustrated in Figure 2-1 was superimposed on the contours and wind speeds at each grid point tabulated and punched onto computer cards. The data were later stored on magnetic tape.

The grid system is numbered from the left-hand bottom corner. The numbers increase from left to right in the positive x-direction of the original data and from bottom to top in the positive z-direction of the original data. The wind speeds are given in units of meters per sec, m s^{-1}, with W_x being positive in the direction of frontal motion, W_z being positive upward and W_y being positive into the plane of the paper.

The wind speed W_x is stored on tape as the wind speed relative to the storm motion. The stored values of wind speed are therefore the values an observer would measure moving along with the storm. To convert to the earth frame of reference the mean motion of the storm must be added to the longitudinal wind speed. The next section describes tables and graphical illustrations of the wind speed profiles. In these cases the mean motion has been added.

2.3.1 Tables of Wind Speed

Tables of thunderstorm wind speed are given in Appendix 2A. The upper portion of the table covers grid stations 1 through 21 and the lower table covers grid stations 21 through 41. (Note column 21 is repeated for symmetry and clarity of presentation.)

The thunderstorm case numbers designation for this report are listed at the top of each table. The letters in parentheses and the following series number corresponds to the thunderstorm designation given by Goff [2-1].

Also listed at the top of the table is the frontal speed, $\overline{W}_x$, and the horizontal length scales for the given wind record. The horizontal extent of each data set varies because of the data reduction procedure. Hence, the length of field, L, in kilometers and the horizontal grid spacing, Δx, are specified on each table. The vertical extent of each field is taken as 500 m with 50 m vertical grid spacing.

2.3.2 Illustrations

Illustrations of the longitudinal, lateral, and vertical wind speeds encountered along a 3° glide slope through each thunderstorm are provided in Appendix 2B. The glide slope is adjusted to terminate at the lower left-hand corner of each streamline plot as illustrated. The ordinate in the wind speed profiles is height, z, nondimensionalized with the length, H = L tan 3°, where L is the length of the wind field. Each profile is the wind seen by an airplane traveling along the flight path line drawn across the streamlines as shown in the upper figures. The flight paths are drawn to terminate in the lower left-hand corner always. Note that the streamlines plotted are relative to the speed of the front which for reference purposes is indicated with the vertical dashed line on the horizontal wind speed profile. The wind speed profiles are relative to the fixed earth frame of reference.

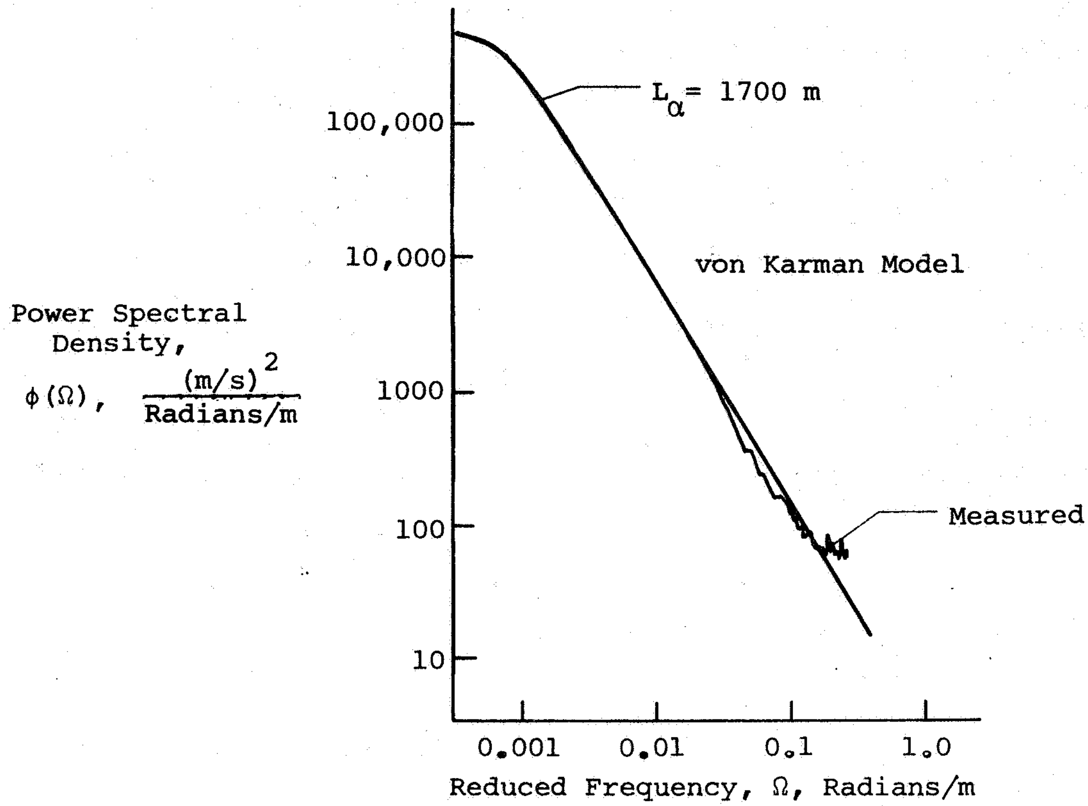
2.3.3 Computer Program for Computing Thunderstorm Wind Speed Profiles

A computer program has been developed which for given input x, z computes the longitudinal, lateral, and vertical wind speeds at that position. The six velocity gradients $\partial W_x/\partial x$, $\partial W_x/\partial z$, $\partial W_z/\partial x$, $\partial W_z/\partial z$, $\partial W_y/\partial x$, and $\partial W_y/\partial z$ are also output by the program. A detailed description and user's instructions for the computer program are provided in Appendix 2C. The computer program also has the option of calling for turbulence which is superpositioned upon the thunderstorm wind field. A non-Gaussian turbulence model based on the technique of Reeves, et al. [2-3] is employed for turbulence simulation.

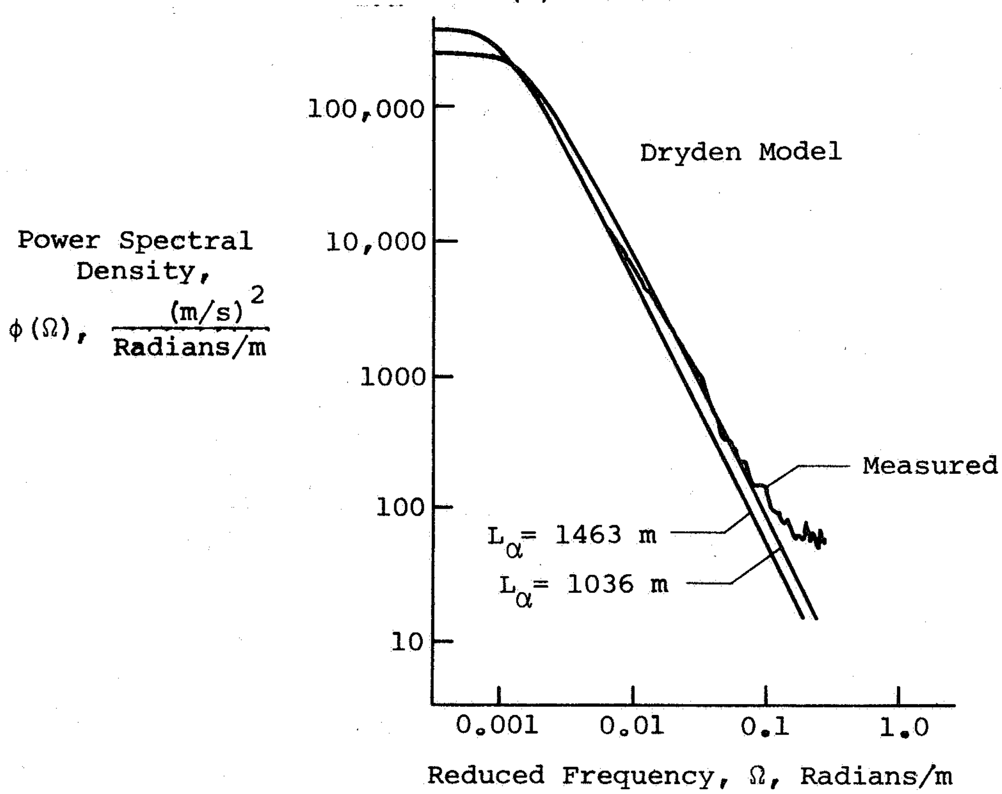
It is intended that this computer program can be used as a subroutine for direct application to fast time flight studies or for fast time computer simulation of aircraft flight through thunderstorms. As an example of the application of the computer program, the reader is referred to Reference [2-4] in which this computer program has been used to study aircraft dynamics in thunderstorms and Reference [2-5] where the data were used for manned flight simulator programming.

2.4 Turbulence in Thunderstorms

Measurements of the power spectral density function for turbulence in thunderstorms has been reported as early as 1962 by Steiner and Rhyne [2-6]. Their data was measured only over the approximate reduced spatial frequency range of 0.004 to 0.4 rad m^{-1}. The theoretical von Karman spectrum follows the data in this frequency range very well as demonstrated by Houbolt, et al. [2-7], in Figure 2-2a. The Dryden spectrum, on the other hand, does not compare as well with the data. However, with the properly chosen length scale a reasonable fit is obtained (see Figure 2-2b). All reported data,



(a) von Karman Model



(b) Dryden Model

Figure 2-2 Measured and Fitted Spectra for Thunderstorm. L∿Integral Length Scale [2-7] however, were measured in the altitude range of 12 to 8 km and moreover they do not extend to low enough frequencies to illustrate at which point the knee of the turbulence spectrum curve occurs. The knee of the power spectral density function is important in many design applications (see Reference [2-8]) and particularly to the empirical value of length scale, L, used in the analytical models of the power spectral density function.

In Reference [2-7] a comparison of the power spectral density function of severe storms with that of cumulus clouds and clear air turbulence is given (see Figure 2-3). One can see from Figure 2-3 that the turbulent spectra for severe storms behaves very similar to that of cumulus clouds and clear air turbulence with the only major difference being higher values of $\phi(\Omega)$ which indicates higher turbulence intensity. Again, these data are measured at very high altitudes and probably do not include effects due to the presence of the ground.

Reference [2-7] computes two values of turbulence intensity. One is computed directly from the experimental data by integrating the power spectral density function over only the limits of the frequency range in which the data have been measured, i.e.,

$$\sigma_1^2 = \int_{\Omega_\ell}^{\Omega_u} \phi(\Omega)d\Omega \tag{2-1}$$

where u and ℓ designate upper and lower, respectively. Spatial frequency designated by Ω is related to cyclic frequency used in Section 3-4 by $n = W\Omega/2\pi$. An alternate method of measuring the turbulence intensity is to compute its value from the autocorrelation function evaluated at zero,

$$\sigma^2 = R(o) = \int_o^\infty \phi(\Omega)d\Omega \tag{2-2}$$

It is found that based on the Dryden model the two measures of turbulence

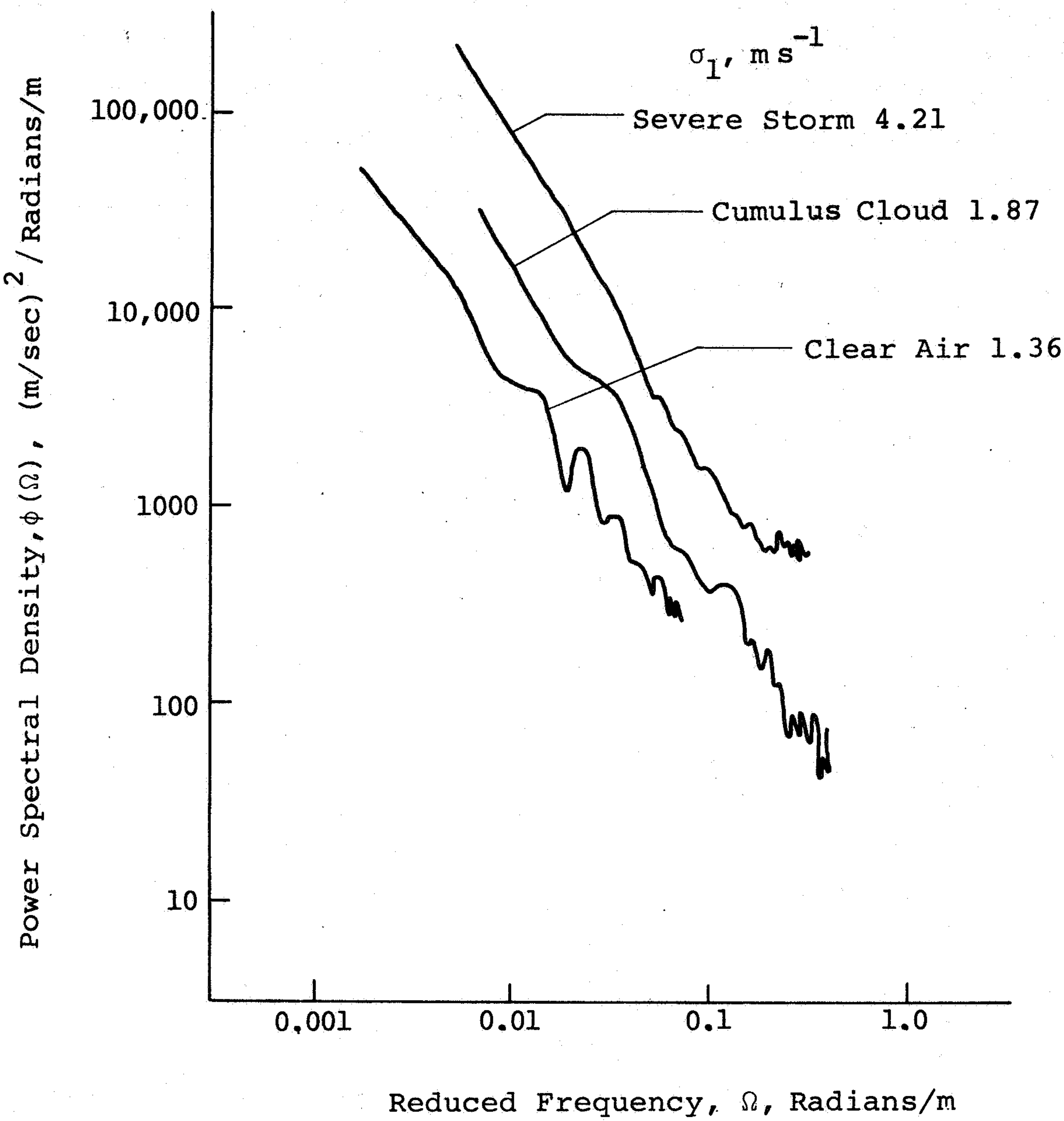


Figure 2-3 Typical Power Spectra of Vertical Component of Turbulence Measured in Clear Air, Cumulus Cloud, and Thunderstorm [2-7]

intensity are related by

$$\sigma^2 = \frac{3}{\pi}\frac{\sigma}{L}\left(\frac{1}{\Omega} - \frac{1}{\Omega_\ell}\right) \tag{2-3}$$

where Ω_u and Ω_ℓ represent the upper and lower limits, respectively, of the range of the turbulent spectrum measurements. Also appearing in this equation is the length scale, L, which is an extremely important parameter in fitting the analytical expressions for the turbulence spectra to the data (see Reference [2-9]).

Although the von Karman spectra tends to fit the data better as illustrated in Figure 2-2, the Dryden spectrum is conventionally used because of its rational form,

$$\begin{aligned}
\phi_{w_x} &= \frac{L_{w_x}\sigma^2_{w_x}}{\pi}\left(\frac{1}{1 + (L_{w_x}\Omega)^2}\right) \\
\phi_{w_y} &= \frac{L_{w_y}\sigma^2_{w_y}}{2\pi}\,\frac{[1 + 3(L_{w_y}\Omega)^2]}{[1 + (L_{w_y}\Omega)^2]^2} \\
\phi_{w_z} &= \frac{L_{w_z}\sigma^2_{w_z}}{2\pi}\,\frac{[1 + 3(L_{w_z}\Omega)^2]}{[1 + (L_{w_z}\Omega)^2]^2}
\end{aligned} \tag{2-4}$$

Evaluation of the Dryden spectrum in a turbulence simulation routine requires knowledge of the length scale, L, and of the turbulence intensity, σ. Houbolt, et al. [2-7] recommend values of L = 1036 m and gives σ_1 values for the vertical fluctuations in the range of 4.88 m s^{-1} to 2.27 m s^{-1} and for the lateral fluctuations of 4.69 m s^{-1} to 2.69 m s^{-1}. Longitudinal values of σ were not measured. Adjusting σ_1 to σ from Equation 2-3 gives values of approximately $10.20 > \sigma_{w_z} > 4.75$ m s^{-1} and $9.82 > \sigma_{w_y} > 5.63$ m s^{-1}.

These values cannot be used directly, however, because the ground is expected to have a strong effect on the turbulence length scale and intensity.

No actual data for L and σ nor for how they vary with height in a thunderstorm below 500 m appears to be available in the literature. Barr, et al. [2-10] postulate a decrease in length scale and intensity at low altitudes. Preliminary results from the analytical model of Lewellen, et al. [2-11] predict increasing values of σ_{w_x} and σ_{w_z} near the ground (see Figure 2-4). In Section 3.4 it is recommended that near the ground the ratio of $\sigma_{w_x}/\sigma_{w_z}$ and $\sigma_{w_y}/\sigma_{w_z}$ be determined from Figure 3-5. The relationships are

$$\sigma_{w_x}/\sigma_{w_z} = [0.177 + 2.74 \times 10^{-3} z]^{-0.4}$$

and

$$\sigma_{w_y}/\sigma_{w_z} = [0.583 + 1.39 \times 10^{-3} z]^{-0.8} \qquad (2\text{-}5)$$

and for lack of a better model this relationship is recommended herein.

Also in Section 3.4, an equation (3-11) for evaluating σ_{w_z} proposed by Barr, et al. [2-10] is given. Evaluation of σ_{w_z} from this equation, however, is very dubious for thunderstorms and is not recommended. For example, a very large and uncommonly observed value of u_* is 2 m s^{-1} or greater (see Section 3.4) which from Equation 3-11 gives a value of σ_{w_z} = 2.6 m s^{-1}. This value which would occur only infrequently in a normal boundary layer is a factor of 1.8 lower than the lowest value of σ_{w_z} measured by Steiner and Rhyne [2-6] bearing in mind, of course, that their data were measured at altitudes between 12 and 8 km.

It is assumed, however, that Steiner and Rhyne's data will extend to lower altitudes and the procedure recommended for evaluating σ_{w_z} is to select a value in the range of $10.20 > \sigma_{w_z} < 4.75$ m s^{-1}. To predict σ_{w_x} and σ_{w_y}, Equation 2-5 should be used.

The length scale of the turbulence may be selected from Figure 2-5 taken from Reference [2-10] where

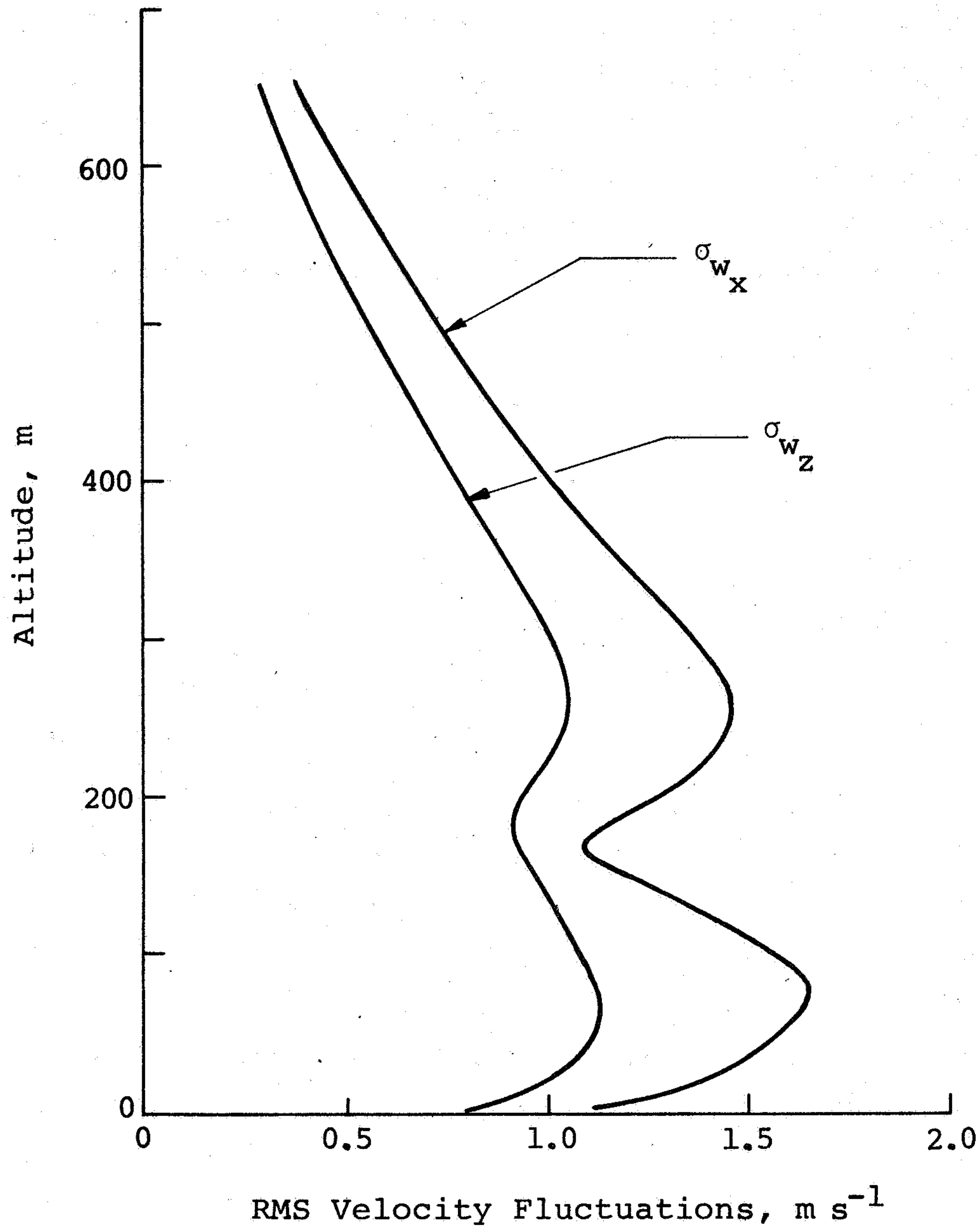


Figure 2-4 Profile of the RMS Values of the Vertical and Head-wind Velocity Fluctuations as Predicted by Lewellen, et al. [2-11]

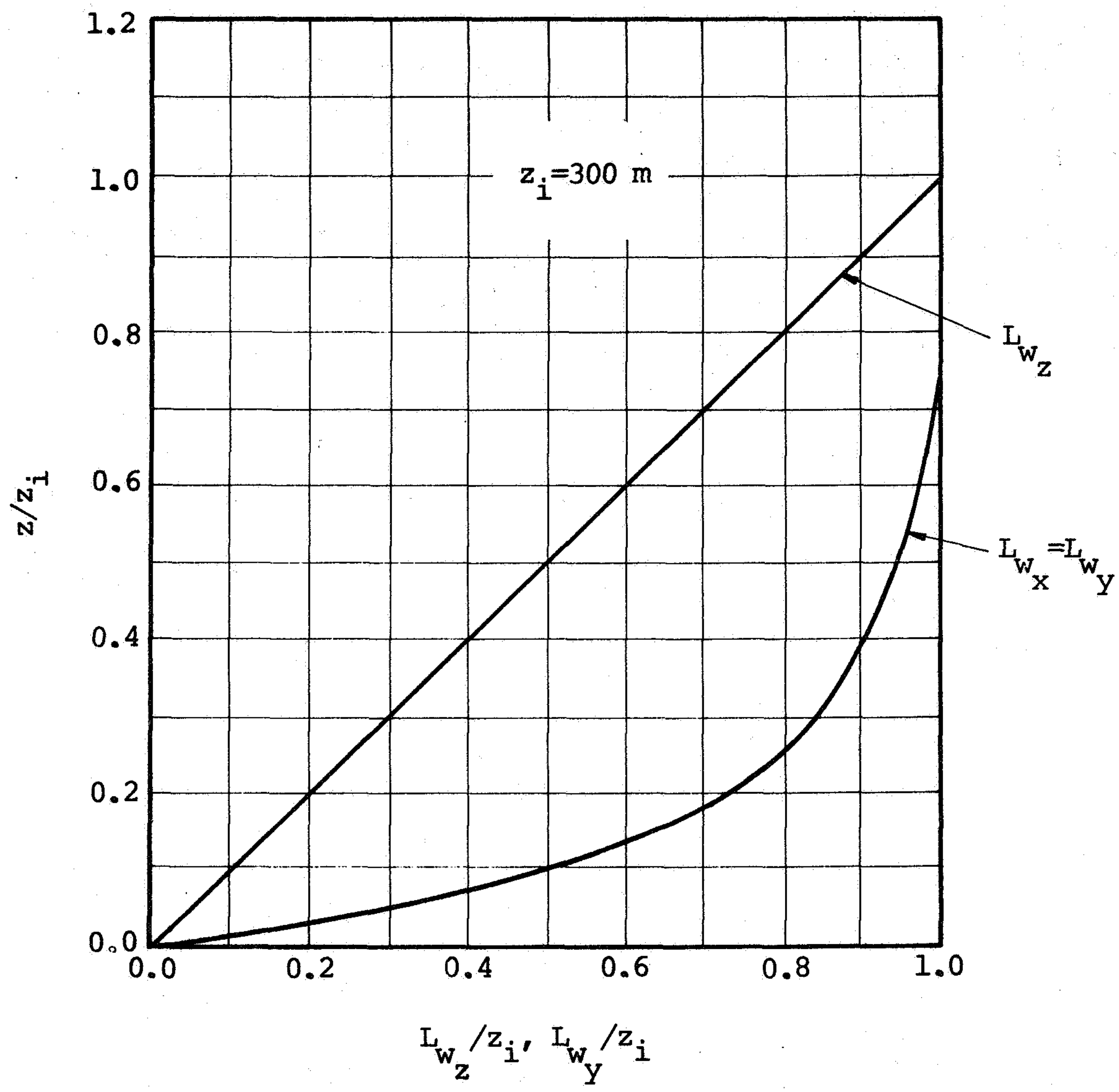


Figure 2-5 Integral Length Scale Description [2-10]

$$L_{w_x} = L_{w_y} = \begin{cases} z, & z \leq 300 \text{ m} \\ 300 \text{ m}, & z \quad 300 \text{ m} \end{cases}$$

$$L_{w_z} = \begin{cases} z[0.177 + 0.00274\, z]^{-1.2}; & z \leq 300 \text{ m} \\ 300 \text{ m}; & z > 300 \text{ m} \end{cases} \qquad (2\text{-}5)$$

Table 2-1 provides values of cyclic frequencies for different velocities of w_x and for spatial frequency of 0.4 and 0.004 radians/m, respectively. It is observed from this table that the tabulated values exceed 0.1 Hz only for the upper limit of Ω and at velocities greater than 10 m s^{-1}. The importance of this observation to the simulation model of wind shear being developed herein is that the wind data utilized in the math model has been integrated over 10 sec periods and, therefore, contains oscillations in the low frequency range of less than 0.1 Hz. Therefore, it is proposed that a turbulence simulation for the current thunderstorm model have all frequencies below 0.1 Hz filtered out using a high pass filter (see Reference [2-12]). In many ways this result is advantageous because the turbulence spectra are better known at high frequencies and can be simulated very well; whereas, low frequency turbulence spectra are not yet well defined. The high frequency range corresponds to the well established inertial subrange [2-13] for which $\phi(\Omega)$ obeys the -5/3 power law. A high pass digital filter program was used with the computer program given in Appendix 2C but is not included in the write-up because it is a standard program given in Reference [2-14] and is too long to be included in this report.

2.5 Statistical Model of Turbulence

In an attempt to make some estimate of the most extreme wind shear which could be encountered during the expected life cycle of a thunderstorm, the 20 thunderstorm cases were taken as a sample for statistical purposes. From this sample, wind speeds along the 20 flight paths illustrated in Appendix 2B were statistically analyzed. Table 2-1 shows the ensemble average of the wind speeds along the flight paths plus the one point standard deviation of each wind speed and the correlations between the wind speed components. These values are defined as shown below for the

TABLE 2-1

ENSEMBLE AVERAGES, STANDARD DEVIATIONS AND CORRELATIONS FOR W_x, W_y AND W_z

z_o	$\langle W_x \rangle$	$\langle W_y \rangle$	$\langle W_z \rangle$
0	9.0700	-0.6850	0.0000
50	9.1895	-1.0350	-0.0519
100	9.7518	-1.2028	-0.1174
150	11.4401	-1.3898	-0.2904
200	12.3359	-1.2510	-0.2539
250	12.5787	-0.1779	-0.0397
300	11.8227	0.2164	-0.0670
350	8.8224	1.1370	0.6620
400	4.3032	2.1131	1.2981
450	1.4670	2.7131	0.8968
500	-0.1681	2.9205	0.4902

z_o	σ_{W_x}	σ_{W_y}	σ_{W_z}
0	4.0341	3.7439	0.0000
50	3.4693	3.4720	0.1404
100	3.7829	3.6212	0.2641
150	3.9754	3.7328	0.4325
200	4.0718	3.7115	0.6148
250	3.8818	4.9743	1.0989
300	3.8244	5.1184	0.8581
350	5.4606	4.7680	0.9819
400	5.7848	5.8223	1.2641
450	5.5734	7.3732	0.6563
500	5.3830	8.2354	0.4774

z_o	$\rho_{W_x W_y}$	$\rho_{W_x W_z}$	$\rho_{W_y W_z}$
0	3.4760	0.0000	0.0000
50	1.9669	0.0184	-0.0567
100	1.5427	-0.1086	0.1101
150	0.3304	-0.7416	-0.0176
200	0.1972	-0.8220	1.2121
250	0.9971	-0.8448	3.8696
300	0.0995	-1.4322	2.1130
350	2.6395	-2.6172	1.2844
400	-4.8549	-2.5340	1.9091
450	-4.6407	-0.5253	-0.5719
500	-2.0084	-0.1117	-1.8076

longitudinal wind speed.

$$\langle W_x \rangle = \frac{1}{N} \sum_{i=1}^{N} W_{x_i} \tag{2-7}$$

$$\sigma_{W_x} = \left[\frac{\sum_{i=1}^{N} (W_{x_i} - \langle W_x \rangle)^2}{N - 1} \right]^{1/2} \tag{2-8}$$

and

$$\rho_{W_x W_y} = \frac{1}{N} \sum_{i=1}^{N} (W_{i_i} - \langle W_x \rangle)(W_{y_i} - \langle W_y \rangle) \tag{2-9}$$

The relationship for the lateral and vertical wind speed and other two correlations are similarly defined.

The results of Table 2-1 allow a trivariate probability density function for the wind components at each point along the flight path to be constructed. A trivariate distribution as described in Reference [2-15] is given by

$$p(W_x, W_y, W_z) = Ce^{-1/2\chi^2} \tag{2-10}$$

where

$$C = 2\pi^{-3/2} |s_{ij}|^{1/2} \tag{2-11}$$

and

$$\chi^2 = \Sigma s_{ii} z_i^2 + 2\Sigma s_{ij} z_i z_j; \quad i = 1, 2, 3 \tag{2-12}$$

The vertical bars designate the determinant of the matrix s_{ij} where

$$s_{ij} = \begin{vmatrix} \sigma_{W_x} & \rho_{W_x W_y} & \rho_{W_x W_z} \\ \cdots & \sigma_{W_y} & \cdots \\ \cdots & \cdots & \sigma_{W_z} \end{vmatrix} \tag{2-13}$$

and z_i is the standardized variate

$$z_i = (W_i - \langle W_i \rangle)/s_{ij};\ j = 1,2,3$$

From this function the probability of the wind vectors at each point can be estimated, however, the mathematics involved is too complicated to present in detail in this report and the reader is referred to Reference [2-15].

There is considerable encouragement that a probability model of thunderstorms could be constructed since the components of $[s_{ij}]$ and the ensemble averages for the 20 storms are reasonably consistent functions of the spatial coordinate x,z. This is demonstrated in Figure 2-6 which shows the variation of $\langle W_z \rangle$, σ_{W_x} and $\rho_{W_x W_y}$ along horizontal lines through the storm at equal increments of Δt = 1 min or $\Delta x/\overline{W}_x$. The lines are at the 400, 300 and 200 m level. The data show well defined variation with time and consistent trends with altitude. Equally consistent results are obtained with the remaining statistical parameters.

These well behaved statistical parameters suggest that a study to develop a complete statistical model of a thunderstorm be carried out. The results of this study would allow simulation of thunderstorms, similar to turbulence simulations, to be performed. Thus, a simulator could be programmed to simulate approaches and landings through a random selection of thunderstorms. Moreover, the statistical model would allow an estimate of the most extreme wind shear associated with a thunderstorm and its frequency of occurrence.

Until such a model is available, the best estimate of the probability of an extreme value in the thunderstorm can be made from the tabulated values of standard deviation (Table 2-1) and the assumption of a Gaussian distribution. For example, one can estimate that at the point z = 250 m on

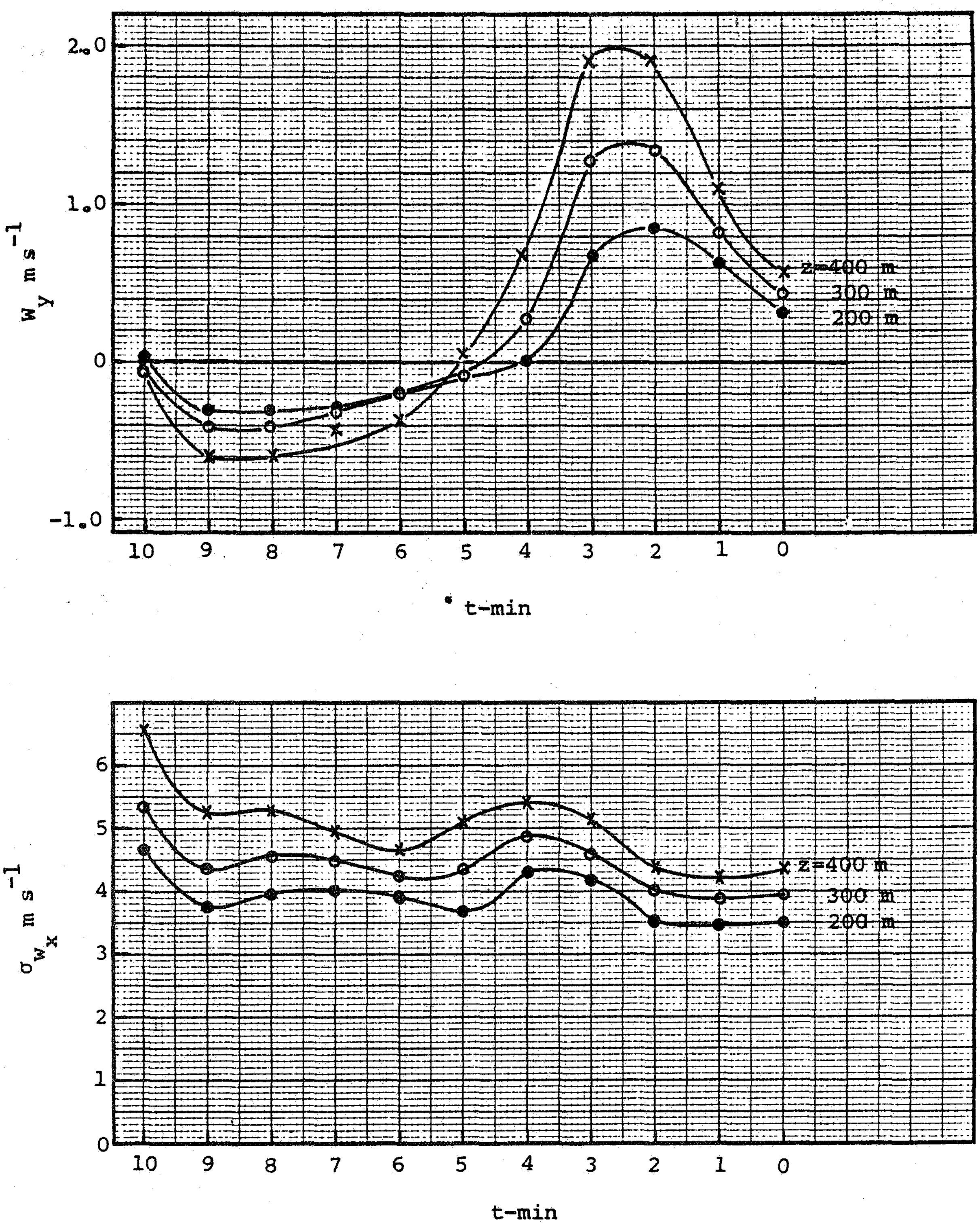


Figure 2-6 Statistical Properties of Thunderstorms along Flight Paths at Constant Elevations of 200, 300 and 400 m

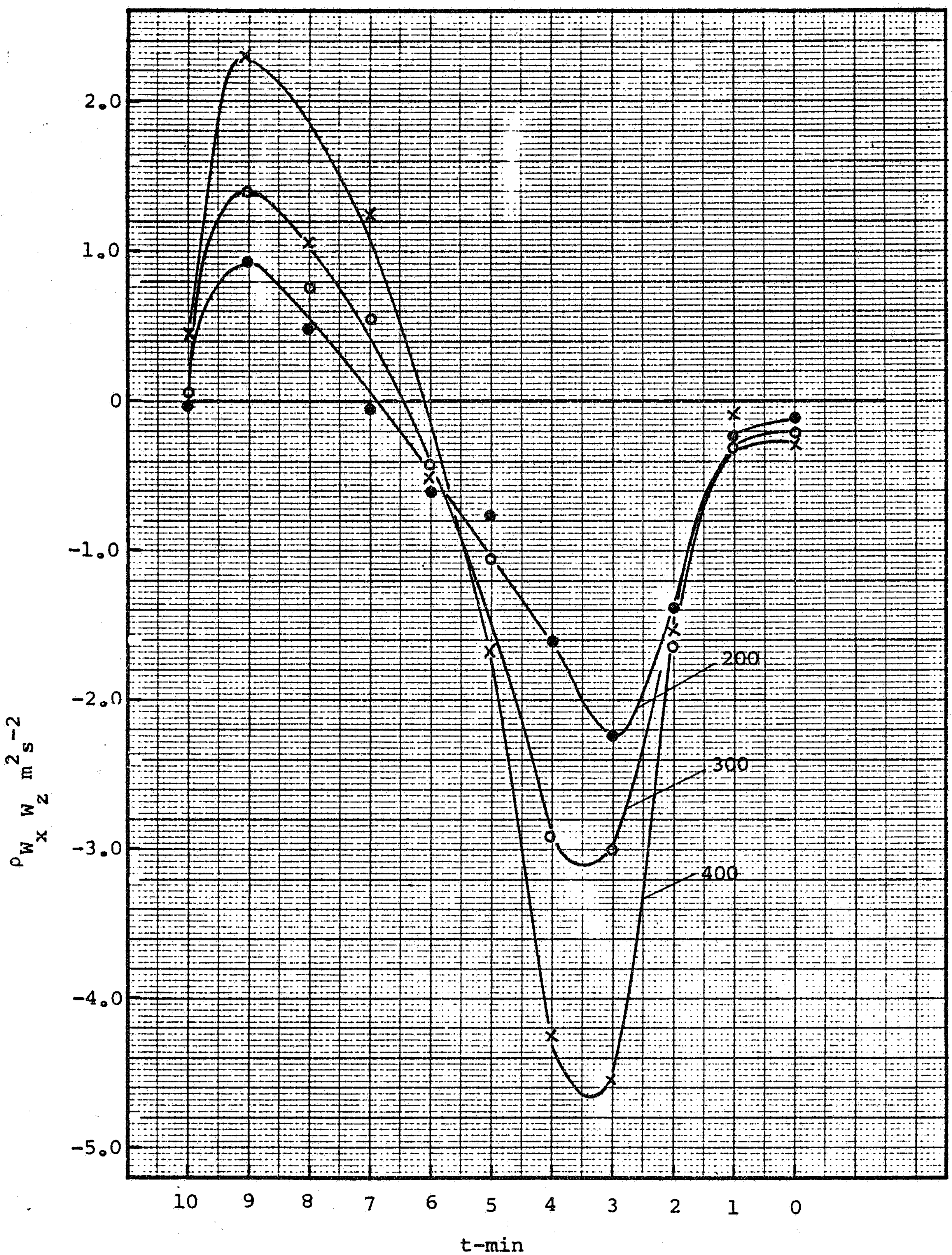


Figure 2-6 Continued

the 3° glide slope W_x will on the average be 12.6 m s^{-1}, there is however a 32% chance that it will be ±3.88 m s^{-1} of that value; a 5% chance that it will be ±7.76 m s^{-1} of that value; etc. This approach assumes that the wind fluctuations at neighboring points are statistically independent which is obviously not the case in view of the significant value of the correlation coefficients also shown in Table 2-1.

Considerably more work is required to produce a satisfactory statistical model of a thunderstorm wind field, however, preliminary analyses conducted on the sample of 20 thunderstorms suggest a meaningful model is feasible and within reach.

2.6 Application of the Thunderstorm Wind Shear Model

The user of the thunderstorm wind shear model simply selects which thunderstorm case is of interest to his simulation problem and generates wind speed profiles for given values of x and z throughout the wind field. The selection of the thunderstorm case must consider two factors: one is the length of horizontal fetch over which the simulation is to be carried out and the other is the severity of the storm which it is desired to simulate.

All profiles have the same vertical extent which is 500 m. However, they have different lengths depending upon the mean motion of the thunderstorm. If a simulation is to be carried out over a significantly long distance in the horizontal direction, one must select the storm which will span the distance of the proposed simulation. Table 2-2 lists the length of each thunderstorm based on its case number. This table can be used to select which thunderstorm case to use in carrying out the simulation where the length of horizontal extent is critical.

The severity of the storms also differ for a number of reasons. One is that the maturity of the storms as they passed over the tower were in different stages of development, another is that the center of the thunderstorm may not have passed over the tower and only the fringes of the storm were recorded. In selecting a storm to have a severity appropriate for the simulation to be carried out, the user may either inspect the graphical illustrations shown in Appendix 2B and thus pick what would appear to be the

TABLE 2-2

HORIZONTAL LENGTH OF EACH STORM RECORD

Case	Length (km)	Case	Length (km)
1	4.00	11	8.16
2	3.28	12	3.64
3	5.71	13	6.35
4	7.69	14	5.13
5	11.43	15	7.41
6	7.27	16	4.44
7	7.84	17	11.43
8	5.56	18	16.00
9	7.41	19	7.14
10	8.51	20	13.33

worst storm relative to the simulation he wishes to perform. Note, however, that the wind profiles shown are based on a specified flight path which terminates at the bottom left-hand corner of each data set and which has a constant 3° glide slope. Therefore, the flight path for which the winds are illustrated may not pass through the worst part of the storm. In this case, the user may examine the tables provided in Appendix 2A and by examining the overall wind fields select from the tables the thunderstorm case which gives either the largest longitudinal wind, largest vertical wind, or the largest lateral wind, which ever may be of interest.

Having chosen the thunderstorm of interest, one would normally wish to predict what the probability of encountering such a thunderstorm would be and with what frequency would such storms occur. Statistical models which would allow this type of risk of exceedance estimate to be made are not available and require further research for their development. The best procedure to achieve some estimate of the probability of encountering such a storm is to utilize the information provided in Section 2.5. Table 2-1 in this section gives the ensemble averaged wind speeds for all 20 thunderstorm cases and the standard deviations of these wind speeds about this mean.

Again, these results are compiled for only those flight paths as specified earlier. The user can, by comparing his selected storm with the ensemble averaged value, determine the number of standard deviations his storm departs from the mean and in this way estimate the probability of the wind field magnitude. The addition or subtraction of standard deviations about the mean at each point along the wind field provides only a crude estimate of the statistics of the thunderstorm wind fields, however. This point is well illustrated by inspection of the coherence between wind speed components provided in Table 2-1. There is a very strong coherence between wind speed components and therefore each point in the wind field does not behave independently. Therefore, it is incorrect to simply add standard deviation at each point but in lieu of a better approach this method can be followed.

The foregoing arguments clearly indicate that there is a need to carry out a more detailed analysis of thunderstorms such that a statistical model which would provide the extreme magnitudes of wind speed and of the wind shear expected to occur in a thunderstorm will be available. The frequency of occurrence of the extreme is also greatly needed.

The turbulence model developed in conjunction with the thunderstorm wind shear model should definitely be used in carrying out any simulation process. The reason for this is that the data utilized to develop the wind shear model predict at most downdrafts of 3 m s^{-1}. Values of downdrafts as high as 15.5 m s^{-1}, however, are reported in [2-16 and 2-17]. These values, however, are undoubtedly averaged over much shorter periods of time than 10 sec for which the data presented herein are averaged. Neither reference gives any information on the averaging time utilized in arriving at the quoted value of 15.5 m s^{-1}. Two models of thunderstorm wind fields that have been developed by Keenan [2-17] are tabulated in Tables 2-3 and 2-4. These wind fields were reconstructed from the flight data recorder of aircraft involved in accidents resulting from flight through severe thunderstorms. Inspection of these tabulated results illustrate that much more extreme downdrafts or downbursts as defined in Reference [2-16] occur in these data sets than in those tabulated in Appendix 2A.

There is at this time conflicting data and opinions as to the maximum magnitude of the downdraft that can occur in a thunderstorm. Although the

Table 2-3 Thunderstorm Wind Field, B10, Similar to Philadelphia/Allegheny Profile [2-17]; HX - Horizontal Station (ft.), Velocities Are Given in Knots and Height in Feet.

	Z	W_x	W_y	W_z
HX =	12200.00			
	0.00	12.50	.00	.00
	75.00	12.50	.00	.00
	100.00	12.50	.00	.00
	150.00	12.50	.00	.00
	200.00	12.50	.00	.00
	300.00	12.50	.00	.00
	400.00	12.50	.00	.00
	500.00	12.50	.00	.00
	600.00	12.50	.00	.00
	700.00	12.50	.00	.00
	800.00	12.50	.00	.00
	1500.00	12.50	.00	.00
HX =	11000.00			
	0.00	-16.00	.00	.00
	75.00	-16.00	.00	.00
	100.00	-16.00	.00	.00
	150.00	-16.00	.00	.00
	200.00	-12.50	.00	.00
	300.00	-10.50	.00	.00
	400.00	-7.50	.00	.00
	500.00	-5.50	.00	.00
	600.00	-2.50	.00	.00
	700.00	-.50	.00	.00
	800.00	5.00	.00	.00
	1500.00	5.00	.00	.00
HX =	9000.00			
	0.00	-27.00	.00	.00
	75.00	-27.00	.00	.00
	100.00	-27.00	.00	.00
	150.00	-27.00	.00	.00
	200.00	-27.00	.00	.00
	300.00	-24.00	.00	.00
	400.00	-20.00	.00	.00
	500.00	-16.50	.00	.00
	600.00	-9.00	.00	.00
	700.00	-.50	.00	.00
	800.00	5.00	.00	.00
	1500.00	5.00	.00	.00
HX =	4000.00			
	0.00	-24.00	.00	.00
	75.00	-24.00	.00	.00
	100.00	-24.00	.00	.00
	150.00	-24.00	.00	.00
	200.00	-24.00	.00	.00
	300.00	-24.00	.00	.00
	400.00	-22.00	.00	.00
	500.00	-13.50	.00	.00
	600.00	-9.00	.00	.00
	700.00	-.50	.00	.00
	800.00	5.00	.00	.00
	1500.00	5.00	.00	.00
HX =	3000.00			
	0.00	-27.50	.00	.00
	75.00	-27.50	.00	.00
	100.00	-27.50	.00	.00
	150.00	-25.00	.00	.00
	200.00	-22.50	.00	.00
	300.00	-18.50	.00	.00
	400.00	-14.00	.00	.00
	500.00	-8.00	.00	.00
	600.00	-4.00	.00	.00
	700.00	1.00	.00	.00
	800.00	5.00	.00	.00
	1500.00	5.00	.00	.00

Table 2-3 Continued

	Z	W_x	W_y	W_z
HX =	6000.00			
	0.00	-22.50	.00	.00
	75.00	-22.50	.00	.00
	100.00	-22.50	.00	.00
	150.00	-19.50	.00	.00
	200.00	-16.50	.00	.00
	300.00	-12.50	.00	.00
	400.00	-6.00	.00	.00
	500.00	-2.00	.00	.00
	600.00	1.00	.00	.00
	700.00	4.00	.00	.00
	800.00	7.50	.00	.00
	1500.00	7.50	.00	.00
HX =	-400.00			
	0.00	-4.00	.00	.00
	75.00	-4.00	.00	-8.89
	100.00	-4.00	.00	-12.50
	150.00	.00	.00	-17.80
	200.00	5.00	.00	-17.80
	300.00	12.50	.00	-17.80
	400.00	12.50	.00	-17.80
	500.00	12.50	.00	-17.80
	600.00	12.50	.00	-17.80
	700.00	12.50	.00	-17.80
	800.00	12.50	.00	-17.80
	1500.00	12.50	.00	-17.80
HX =	-1000.00			
	0.00	-1.00	.00	.00
	75.00	-1.00	.00	-8.90
	100.00	-1.00	.00	-13.40
	150.00	5.00	.00	-17.80
	200.00	12.50	.00	-17.80
	300.00	12.50	.00	-17.80
	400.00	12.50	.00	-17.80
	500.00	12.50	.00	-17.80
	600.00	12.50	.00	-17.80
	700.00	12.50	.00	-17.80
	800.00	12.50	.00	-17.80
	1500.00	12.50	.00	-17.80
HX =	-3400.00			
	0.00	26.00	.00	.00
	75.00	26.00	.00	-8.90
	100.00	26.00	.00	-13.40
	150.00	19.50	.00	-17.80
	200.00	12.50	.00	-17.80
	300.00	12.50	.00	-17.80
	400.00	12.50	.00	-17.80
	500.00	12.50	.00	-17.80
	600.00	12.50	.00	-17.80
	700.00	12.50	.00	-17.80
	800.00	12.50	.00	-17.80
	1500.00	12.50	.00	-17.80
HX =	-4000.00			
	0.00	29.00	.00	.00
	75.00	29.00	.00	-8.90
	100.00	29.00	.00	-13.40
	150.00	25.00	.00	-17.80
	200.00	20.00	.00	-17.80
	300.00	12.50	.00	-17.80
	400.00	12.50	.00	-17.80
	500.00	12.50	.00	-17.80
	600.00	12.50	.00	-17.80
	700.00	12.50	.00	-17.80
	800.00	12.50	.00	-17.80
	1500.00	12.50	.00	-17.80

Table 2-3 Continued

Z	W_x	W_y	W_z
HX = -[illegible].00			
0.00	46.00	.00	.00
75.00	46.00	.00	.00
100.00	46.00	.00	.00
150.00	43.00	.00	.00
200.00	40.00	.00	.00
300.00	36.00	.00	.00
400.00	29.50	.00	.00
500.00	25.50	.00	.00
600.00	23.00	.00	.00
700.00	20.00	.00	.00
800.00	17.00	.00	.00
1500.00	17.00	.00	.00
HX = -6000.00			
0.00	52.50	.00	.00
75.00	52.50	.00	.00
100.00	52.50	.00	.00
150.00	52.50	.00	.00
200.00	52.00	.00	.00
300.00	47.50	.00	.00
400.00	[illegible]	.00	.00
500.00	36.00	.00	.00
600.00	32.00	.00	.00
700.00	25.50	.00	.00
800.00	20.00	.00	.00
1500.00	20.00	.00	.00
HX = -9000.00			
0.00	52.50	.00	.00
75.00	52.50	.00	.00
100.00	52.50	.00	.00
150.00	52.50	.00	.00
200.00	52.50	.00	.00
300.00	49.00	.00	.00
400.00	47.50	.00	.00
500.00	43.50	.00	.00
600.00	34.00	.00	.00
700.00	25.50	.00	.00
800.00	20.00	.00	.00
1500.00	20.00	.00	.00
HX = -13000.00			
0.00	52.50	.00	.00
75.00	52.50	.00	.00
100.00	52.50	.00	.00
150.00	52.50	.00	.00
200.00	52.50	.00	.00
300.00	49.00	.00	.00
400.00	47.50	.00	.00
500.00	43.50	.00	.00
600.00	34.00	.00	.00
700.00	25.50	.00	.00
800.00	20.00	.00	.00
1500.00	20.00	.00	.00
HX = -15000.00			
0.00	51.50	.00	.00
75.00	51.50	.00	.00
100.00	51.50	.00	.00
150.00	45.80	.00	.00
200.00	40.00	.00	.00
300.00	37.00	.00	.00
400.00	34.00	.00	.00
500.00	31.50	.00	.00
600.00	28.50	.00	.00
700.00	25.50	.00	.00
800.00	20.00	.00	.00
1500.00	20.00	.00	.00

Table 2-3 Continued

Z	W_X	W_Y	W_Z
HX = -16500.00			
0.00	12.50	.00	.00
75.00	12.50	.00	.00
100.00	12.50	.00	.00
150.00	12.50	.00	.00
200.00	12.50	.00	.00
300.00	12.50	.00	.00
400.00	12.50	.00	.00
500.00	12.50	.00	.00
600.00	12.50	.00	.00
700.00	12.50	.00	.00
800.00	12.50	.00	.00
1500.00	12.50	.00	.00

6 TURBULENCE PARAMETERS, WIND PROFILE: B10

20.00	3.40	2.70	2.34	105.70	49.70	10.40
100.00	4.05	3.46	3.53	216.70	134.20	53.00
200.00	4.43	3.95	4.35	306.50	213.50	106.00
400.00	4.85	4.50	5.36	433.50	339.60	212.00
600.00	5.11	4.86	6.05	530.90	445.60	318.00
1500.00	5.74	5.78	7.94	840.90	824.50	795.30

Table 2-4 Thunderstorm Wind Field, B11, Similiar to Kennedy/Eastern Profile, [2-17]; HX - Horizontal Station (ft.), Velocities Are Given in Knots and Height in Feet.

HX = 3000.00			
20.00	-16.90	3.00	.00
150.00	-19.40	7.50	-.20
250.00	-20.10	8.00	-.70
350.00	-23.60	9.00	2.20
450.00	-20.80	10.00	14.70
550.00	-26.70	11.00	-9.70
650.00	-13.50	12.00	-9.70
800.00	-4.60	12.80	-6.50
1200.00	-4.00	11.20	-3.30
1500.00	-4.80	10.00	-3.40
HX = 1000.00			
20.00	-15.50	3.00	.00
150.00	-20.30	7.50	-.40
250.00	-21.40	8.00	-2.50
350.00	-23.80	9.00	-1.10
450.00	-26.60	10.00	-2.50
550.00	-26.00	11.00	-8.00
650.00	-23.50	12.00	-12.90
800.00	-5.60	12.80	-7.70
1200.00	-3.10	11.20	-7.40
1500.00	-2.30	10.00	-6.10

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Table 2-4 Continued

	Z	W_x	W_y	W_z
HX =	-1000.00			
	20.00	-13.20	3.00	.00
	150.00	-19.90	7.50	.00
	250.00	-22.20	8.00	-3.60
	350.00	-20.80	9.00	-6.00
	450.00	-25.60	10.00	.00
	550.00	-28.40	11.00	.00
	650.00	-23.10	12.00	-11.40
	800.00	-9.10	12.80	-10.90
	1200.00	-2.70	11.20	-8.40
	1500.00	-2.40	10.00	-9.00
HX =	-3000.00			
	20.00	-5.50	3.00	.00
	150.00	-9.90	7.50	-.90
	250.00	-10.40	8.00	-6.10
	350.00	-10.40	9.00	-17.90
	450.00	-11.10	10.00	-27.70
	550.00	-7.00	11.00	-30.60
	650.00	-4.10	12.00	-27.00
	800.00	.00	12.80	-16.60
	1200.00	.00	11.20	-14.80
	1500.00	.00	10.00	-14.80
HX =	-5000.00			
	20.00	5.50	3.00	.00
	150.00	9.90	7.50	-.90
	250.00	10.40	8.00	-6.10
	350.00	10.40	9.00	-17.90
	450.00	11.10	10.00	-27.70
	550.00	7.00	11.00	-30.60
	650.00	4.10	12.00	-27.70
	800.00	.00	12.80	-16.60
	1200.00	.00	11.20	-14.80
	1500.00	.00	10.00	-14.80
HX =	-6000.00			
	20.00	11.90	3.00	.00
	150.00	17.50	7.50	-.70
	250.00	18.80	8.00	-6.10
	350.00	20.80	9.00	-10.30
	450.00	16.80	10.00	-12.30
	550.00	17.40	11.00	-24.00
	650.00	6.20	12.00	-24.60
	800.00	5.60	12.60	-13.40
	1200.00	2.40	11.20	-14.00
	1500.00	1.50	10.00	-12.30
HX =	-7000.00			
	20.00	13.20	3.00	.00
	150.00	19.90	7.50	.00
	250.00	22.20	8.00	-3.60
	350.00	20.80	9.00	-6.00
	450.00	25.60	10.00	.00
	550.00	28.40	11.00	.00
	650.00	23.10	12.00	-11.40
	800.00	9.10	12.80	-10.90
	1200.00	2.70	11.20	-8.40
	1500.00	2.40	10.00	-9.00
HX =	-8000.00			
	20.00	14.50	3.00	.00
	150.00	20.80	7.50	-.40
	250.00	21.50	8.00	-2.60
	350.00	23.10	9.00	-4.10
	450.00	[illegible]	10.00	[illegible]
	[illegible]	[illegible]	[illegible]	.00
	650.00	25.40	12.00	11.90
	800.00	7.80	12.80	9.70
	1200.00	3.20	11.20	8.90
	1500.00	2.40	10.00	7.00

Table 2-4 Continued

Z	W_x	W_y	W_z
HX = -9000.00			
20.00	15.50	3.00	.00
150.00	20.30	7.50	-.40
250.00	21.40	8.00	-2.50
350.00	23.80	9.00	-1.10
450.00	26.60	10.00	2.50
550.00	26.00	11.00	-8.00
650.00	23.50	12.00	-12.90
800.00	5.60	12.80	-7.70
1200.00	3.10	11.20	-7.40
1500.00	2.30	10.00	-6.10
HX = -10000.00			
20.00	16.80	3.00	.00
150.00	20.10	7.50	-.20
250.00	20.80	8.00	-.90
350.00	23.80	9.00	.00
450.00	25.50	10.00	6.00
550.00	25.30	11.00	-12.90
650.00	20.80	12.00	-12.90
800.00	4.90	12.80	-8.10
1200.00	3.30	11.20	-5.60
1500.00	6.10	10.00	-4.40
HX = -11000.00			
20.00	16.90	3.00	.00
150.00	19.40	7.50	-.20
250.00	20.10	8.00	-.70
350.00	23.60	9.00	2.20
450.00	20.80	10.00	14.70
550.00	26.70	11.00	-9.70
650.00	13.50	12.00	-9.70
800.00	4.60	12.80	-6.50
1200.00	4.00	11.20	-3.30
1500.00	4.80	10.00	-3.40
HX = -13000.00			
20.00	17.10	3.00	.00
150.00	19.30	7.50	.00
250.00	20.00	8.00	-.20
350.00	23.20	9.00	2.20
450.00	26.60	10.00	-2.50
550.00	17.80	11.00	-4.40
650.00	15.60	12.00	-3.00
800.00	6.60	12.80	-1.90
1200.00	6.10	11.20	-1.50
1500.00	5.80	10.00	-.90
HX = -31000.00			
20.00	9.60	3.00	.00
150.00	19.10	7.50	.00
250.00	20.10	8.00	.00
350.00	22.90	9.00	.00
450.00	26.70	10.00	.00
550.00	19.00	11.00	.00
650.00	15.80	12.00	.00
800.00	7.00	12.80	.00
1200.00	6.50	11.20	.00
1500.00	6.00	10.00	.00

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20.00	3.40	2.70	2.34	105.70	49.70	10.40
100.00	4.05	3.46	3.53	216.70	134.20	53.00
200.00	4.43	3.95	4.35	306.50	213.50	145.00
400.00	4.85	4.50	5.36	433.50	339.60	212.00
600.00	5.11	4.86	6.05	530.90	445.60	318.00
1500.00	5.74	5.78	7.94	840.90	524.50	745.30

10 sec average data of Goff [2-1] will have lower values than the peak downdraft wind speeds reported by Fujita [2-16], the discrepancy in the values cannot be completely contributed to averaging time. A recent report by Alexander [2-18] gives a statistical summary of vertical wind speed data recorded at NASA's 150 m ground wind tower facility, Kennedy Space Center, Florida. One year of continuous around-the-clock vertical wind speed measurements were processed to determine the intensity, frequency, time of occurrence, etc., of the daily maximum vertical gust. Both updrafts and downdrafts were studied. These values represent 0.1 sec averages and the maximum vertical downdraft recorded is 9.3 m s^{-1} although data recorded specifically during the hurricane Agnes indicated a downdraft in excess of 11.9 m s^{-1}.

Sinclair [2-19] indicates that downdrafts at 1000 m for an Oklahoma thunderstorm may be considerably in excess of the 15.5 m s^{-1} recorded in Reference [2-16]. Sinclair has experienced and measured downdrafts as high as 28 m s^{-1} based on a 1/25 sec averaging period. Finally, the numerical model of Williams, et al. [2-20] does not predict wind speed downdrafts greater than 10 m s^{-1}.

Thus, it is evident that research is needed to bring together the data currently available and to resolve the magnitude of the maximum downdraft which can occur within a thunderstorm. This would allow the current simulation model to be updated by superimposing turbulence fluctuations of realistic magnitude on quasi-steady wind fields. For the time being, however, to provide an estimate of wind fields which would be consistent with the higher values of vertical wind speed reported in References [2-16 and 2-17] consider the following.

If the wind shear model based on the thunderstorm data from Goff [2-1] incorporates into the turbulence simulation fluctuations which are based on $4.75 \le \sigma_{W_Z} \le 10.2$ m s^{-1} recorded at 12 to 8 km as described earlier in Section 2.4, very high downdrafts will be computed. For example, taking the average value of $\sigma_{W_Z} = 7.5$ m s^{-1} and adding to that the 10 sec average wind speed of approximately 2.5 m s^{-1}, a value of 10 m s^{-1} is obtained for one standard deviation and a value of 17.5 m s^{-1} for two standard deviations. The reported value of 15.5 m s^{-1} mentioned earlier is slightly less than two standard deviations about the 10 sec mean. Thus, statistically it is clear that downdrafts of 15 m s^{-1} or greater can readily occur in thunderstorms if the turbulence intensities at altitudes of 12 to 8 km extend to the ground. However, turbulence intensity is normally attenuated near the ground and it is not confirmed that such high values exist there. Until this is experimentally resolved, it is recommended that the model of thunderstorm wind shear based on the extensive data from Goff [2-1] should have turbulent fluctuations superimposed with a standard deviation of $\sigma_{W_z} \simeq 7.5$ m s^{-1}. The downdraft magnitudes reported in accident investigation will then be achieved in the simulation.

It is anticipated that the proposed turbulence simulation model based on the work of Reeves, et al. [2-3] will provide a realistic turbulence simulation to accompany the wind shear model proposed in this report. However, a better simulation of the large downdraft fluctuations that occur in a thunderstorm can be achieved by utilizing a model of turbulence which includes coherence between different levels of the atmosphere or between different positions in the storm. Such a model has been preliminarily developed by Perlmutter and Frost [2-21]; however, this model requires further perfection and the coherence function associated with thunderstorms must be developed to permit its use.

An alternative explanation of why the data of Goff does not contain downbursts of the intensity reported in [2-16 and 2-17] is that the 20 thunderstorms investigated may not contain a "spearhead echo" type storm [2-16] or the measured data may not encompass the downdraft portion of the storm. Fujita [2-16] defines a downburst as $W_z = 3.6$ m s^{-1} at the 300 m level. The averaging time related to this wind speed is not specified, and it is not known whether this represents a peak gust or a value averaged over some interval of time which is undoubtedly less than 10 sec. The data of Goff [2-1] do not indicate any values of W_z that equal or exceed the 3.6 m s^{-1} definition of a downburst. There are a few values, however, that do approach the 3.6 m s^{-1} level; for example, thunderstorm cases 8 and 11 shown in Table 2-5 which lists the maximum and minimum values of W_z recorded at the 300 m level in the data utilized to construct the thunderstorm wind shear model given in this report. The fact that no downbursts are recorded is not surprising, however, because obviously the chance of a downburst being directly over the tower the instant of maximum intensity is extremely small.

TABLE 2-5

MAXIMUM AND MINIMUM VERTICAL VELOCITIES AT 300 m LEVEL IN DATA OF GOFF [2-1]

Case	$W_{z_{max}}$ (m s^{-1})	$W_{z_{min}}$ (m s^{-1})	Case	$W_{z_{max}}$ (m s^{-1})	$W_{z_{min}}$ (m s^{-1})
1	1.6	-2.5	11	1.8	-3.0
2	3.0	-1.2	12	2.0	-0.9
3	2.6	-1.1	13	3.2	-0.7
4	3.0	0.7	14	2.1	-1.0
5	3.0	-1.3	15	2.0	-0.5
6	3.7	-1.5	16	2.0	-1.0
7	1.2	-2.1	17	1.1	-0.5
8	4.0	-3.0	18	1.0	-1.0
9	4.1	-0.1	19	2.0	-2.0
10	3.0	-1.2	20	0.2	-1.1

Fujita [2-22] points out the probability of an airport being under the influence of a spearhead echo is very low and is probably less than 2 percent of the thunderstorm probability. Moreover, he notes that the location of aviation hazards for the extreme downburst is limited to only a fraction of the spearhead echo area. With this in mind it is relatively easy to believe that the data of Goff do contain a few storms of the magnitude approaching those types defined as spearhead echo by Fujita. Moreover, since several of the storms clearly record downdrafts approaching the magnitude of downbursts for 10 sec averaged wind speed, it is envisioned that significantly higher downward gust for a shorter, say, 3 sec average are contained in the original data.

The data set illustrated in Tables 2-3 and 2-4 is being punched on cards and will be included with thunderstorm data now stored on magnetic tape. It is believed, however, that the current data set utilizing the appropriate turbulent intensities will provide a valid simulation of thunderstorms for flight/hazard simulation studies. The larger selection of thunderstorms, 20 in number, enables a manned flight simulation study to provide the pilot with several different thunderstorm situations that do not duplicate those that he has negotiated in previous tests. Thus, he cannot learn a given storm. By selecting the same sequence of thunderstorms, a second pilot involved in the same test program can be exposed to the identical test pattern utilized for the first pilot with neither pilot flying the same storm more than once.

Finally, it is called to the attention of the user, that in carrying out a simulation where avionics using ground wind speeds as inputs are being studied, the storm must be considered to be passing over the airport or anemometer from which the ground wind is being determined at the speed of the gust front, $\overline{W}_x$. Therefore, the length of the thunderstorm record used in the simulation must be sufficiently long that the location of the assumed anemometer at the airport has not moved out of the range of data set during the time taken by the aircraft to complete its approach.

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SECTION 3.0

NEUTRAL AND STABLE BOUNDARY LAYERS

The data set utilized in formulating a mathematical model for wind shear or wind fields associated with neutral and stable boundary layers relies mainly on the work of Clarke and Hess [3-1]. Although numerous analytical models for boundary layers, both under neutral and stable conditions were available in the literature, these were in general based on the assumption of constant stress which is valid only to the first 50 or 100 m of the atmospheric boundary layer. Other analytical models which did not evoke this assumption and included the influence of turbulence of the atmospheric boundary layer were generally highly mathematical and required numerical solution with a computer. Therefore, the data set of [3-1], which are presented in the form of contour maps of constant longitudinal and lateral wind speeds as a function of height, z, and the stability of the atmosphere expressed by the stability parameter, μ, allowed tabulation of the wind fields on a grid system. These tabulated data were then coupled with a table lookup computer program to provide the fast time wind speed model for flight hazard simulation.

None of the data sets or mathematical models available in the literature for boundary layers (see Reference [3-2]) incorporate horizontal variation of wind speed. Hence, the wind shear models for neutral and stable boundary layers reported herein depend only on the vertical scale, z. It should be borne in mind, however, that terrain features indigenous to each landing site can influence the spatial gradient of the wind speed horizontally and also introduce a possible vertical wind speed component. Fortunately, most airport terrain is relatively flat and not surrounded by high mountains or sharp cliffs which create flow disturbances, both vertically and horizontally in the wind. Therefore, the wind shear model described in the following section is expected to present a valid simulation of wind shear in terminal areas of the typical airport. However, indiscriminate application of the model is cautioned against until further studies of wind fields over irregular terrain become available.

3.1 Data Source

Boundary layer data are presented in the form of horizontal and lateral wind vector components. The boundary layers are described over flat uniform homogeneous terrain and therefore have no vertical component of wind speed or dependence on the x-coordinate. Of course, when turbulence fluctuations are superimposed as described in Section 3.4, a vertical component can occur. The wind speed profile is thus dependent only on the height, z, and on the stability of the atmosphere characterized by the stability parameter, μ. The data set used in the boundary layer model is based on the results of the extensive wind speed measurements reported in Reference [3-1]. Also, the influence of baroclinicity is neglected and is justified for this data in Reference [3-1].

Wind speeds and temperatures were measured over a very flat, smooth surface having a mean surface roughness parameter, z_0, of approximately 3.5 mm. Hourly double theodolite observations of pilot balloons were taken at five stations for 40 days. Micrometeorological observations were taken at two of the five stations. Wind profiles were measured at 0.5, 1, 2, 4, 8 and 16 m while temperature differences were measured at one station between 1 and 2 m, 2 and 4 m. Values of u_* were estimated by the drag coefficient method and values of surface heat flux by means of temperature and wind profiles. Surface pressures were measured at each of the five stations and radiosonde measurements were made every three hours at the central station. In addition, three hourly surface pressure and temperature data from 14 stations at distances up to 350 km away were used to augment the data obtained by the research expedition.

Geostrophic winds were determined from the data by using second order curve fitting procedures on the pressure data. Thermal winds were determined using temperatures from a surface network reported every three hours and from a temperature field measured each day at 1500 hours. Interpolation from the three-hour data set were primarily used in assessing baroclinicity which was shown to be small. A second set of thermal wind estimates based on twice daily radiosonde data from a network of five stations were also made. Reference [3-1] reports that surface geostrophic winds were well determined as evidenced by the high correlation (93 percent) with observed winds; however, no claim of high accuracy in estimating thermal winds is made in the report.

These data thus reduced were reported by Clark and Hess [3-1] in the form of contour maps of winds as a function of dimensionless height, $\hat{z} = zf/u_{*o}$, and of the stability parameter, $\mu = \kappa u_*/fL'$. The contours of the map are lines of constant $\Delta\hat{W}_x = \hat{W}_x(\hat{z} = 0.15) - \hat{W}_x(\hat{z})$ and $\Delta\hat{W}_y = \hat{W}_y(\hat{z}) - \hat{W}_y(\hat{z} = 0.15)$, respectively, where $\hat{W}$ is the dimensionless wind speed W/u_*. The symbol f is the Coriolis parameter (here, treated positive in both hemispheres with a right-hand coordinate system implied in the Northern hemisphere). For use in this report, the data were converted to a 34 x 11 grid as illustrated in Figure 3-1. The data were then stored on magnetic tape and a computer look-up routine developed for interpolating the values of $\hat{W}_x$ and $\hat{W}_y$ for given values of z and μ. The tabulated data are given in Appendix 3A, illustrative wind speed profiles are given in Appendix 3B, and a computer program for looking up and interpolating the data is given in Appendix 3C.

3.2 Presentation of Data

The data are presented in a right-hand coordinate system with $\hat{W}_x$ positive in the direction from left to right and $\hat{W}_y$ positive into the plane of the paper.

The values of μ range from -333.34 to 216.67 in increments of $\Delta\mu$ = 16.67. This unusual increment size was chosen for convenience in extracting the data from the contour plots. Values of $\hat{z}$ range from 0.001 to 0.15 in increments of $\Delta\hat{z}$ = 0.0149.

Because of the similarity and scaling laws used in reduction of the data, values of wind below $\hat{z}$ = 0.001 are not given. To establish the profile from $\hat{z}$ = 0.001 to zero the log-linear wind speed profile was used (for a description of the log-linear wind speed profile see Reference [3-2]). Values of $\hat{W}_x(\hat{z})$ below $\hat{z}$ = 0.001 are determined from

$$\hat{W}_x(\hat{z}) = \frac{1}{\kappa}\{\ln(Ro\ \hat{z} + 1) + 4.5\ \hat{z}\mu/\kappa\}; \quad \mu \geq 0,\ 0 \leq \hat{z} \leq 0.001 \qquad (3\text{-}1)$$

where Ro is the Rossby number defined as $Ro = u_*/fz_o$. The variable z_o is the

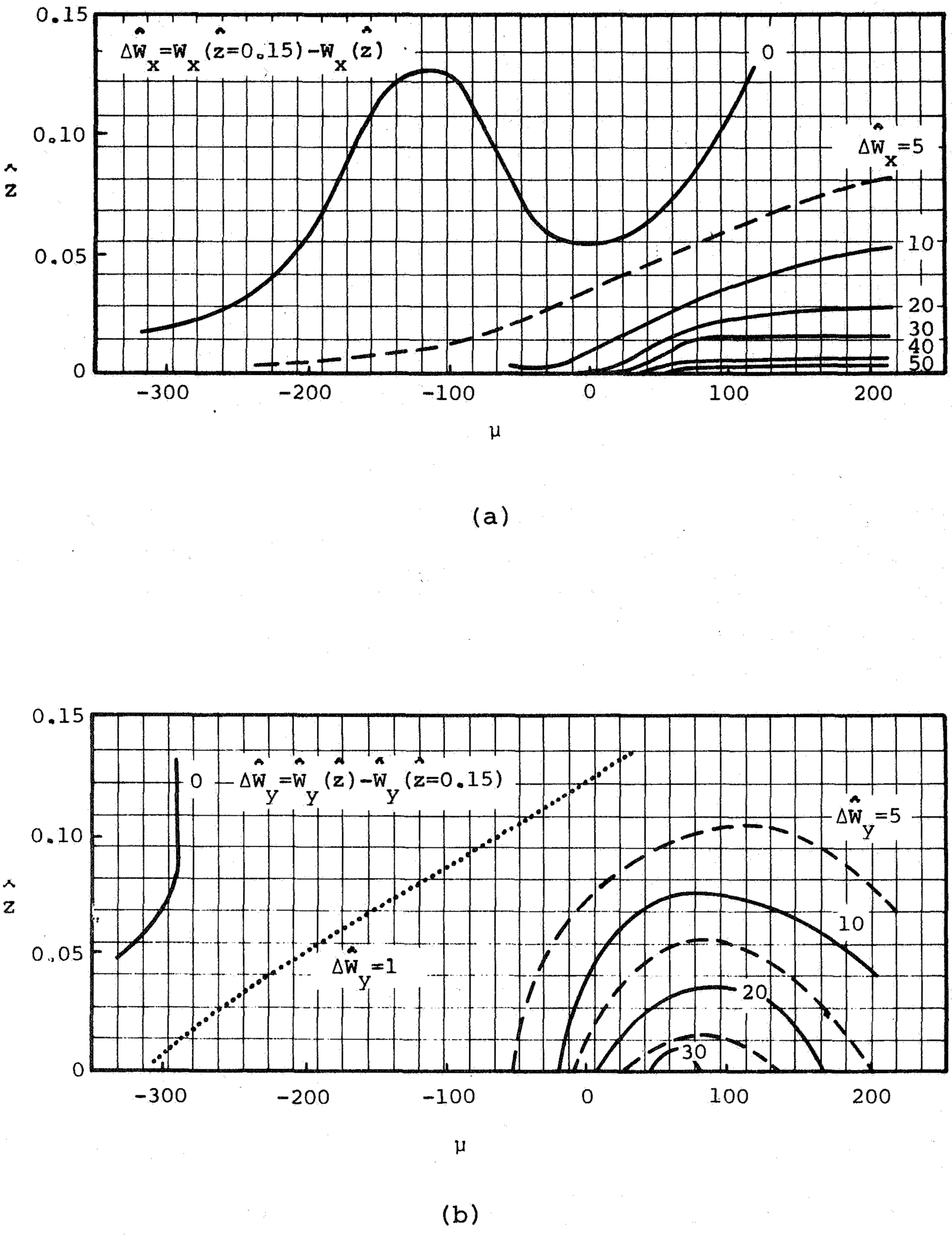

Figure 3-1 Grid System Superimposed on the Data of Clarke and Hess [3-1]

empirically determined surface roughness. Typical values of z_0 are given in Reference [3-2]. The value of $\hat{W}_y$ is zero for $0 \leq \hat{z} \leq 0.001$. Introducing $\hat{z} \doteq 0.001$ into the equation gives the value of wind speed to which all the tabulated longitudinal wind speeds are referenced.

3.3 Mean Wind Speeds

This section considers values of the mean wind fields computed from the mathematical model of the neutral and the stable boundary layers. Although the data include the range of unstable condition, i.e., $-334.34 \leq \mu < 0$, strong wind shear is not normally associated with unstable boundary layers and hence no values of winds for this range of μ are given.

The wind data are averaged over a 10 minute period or longer and thus represent mean values. A model of turbulence for the neutral and stable boundary layer is given in Section 3.4 which is superimposed to give the random instantaneous wind speed.

The grid system used in storing the data is numbered from the bottom left-hand corner. The numbers increase from left to right in the direction of increasing μ and from bottom to top in the direction of increasing $\hat{z}$. Thus column 1 corresponds to $\mu = -333.34$ and column 34 corresponds to $\mu = 216.67$ where row 1 corresponds to $\hat{z} = 0.001$ and row 11 corresponds to $\hat{z} = 0.15$.

3.3.1 Tables of Wind Speed

Tables of the longitudinal and lateral wind speeds $\hat{W}_x(\hat{z})$ and $\hat{W}_y(\hat{z})$ for neutral and stable boundary layers, i.e., $\mu \geq 0$, are given in Appendix 3A. These values are computed from the tabulated wind differences from the relationship

$$\hat{W}_x(\hat{z}) = \Delta\hat{W}_x(\hat{z} = 0.001) - \Delta\hat{W}_x(\hat{z}) + \hat{W}_x(\hat{z} = 0.001) \quad (3\text{-}2)$$

and

$$\hat{W}_y(\hat{z}) = \Delta\hat{W}_y(\hat{z}) - \Delta\hat{W}_y(\hat{z} = 0.001) \quad (3\text{-}3)$$

where from Equation 3-1 evaluated at $\hat{z} = 0.001$,

$$\hat{W}_x(\hat{z} = 0.001) = \kappa^{-1}[\ell n(0.001\ Ro + 1) + 0.01125\ \mu] \tag{3-4}$$

3.3.2 Illustrations

The longitudinal and lateral wind speeds which would be encountered along a 3° glide slope are plotted for various stability conditions and Rossby numbers in Appendix 3B. Height is expressed in meters, m, on the vertical scale and wind speeds are expressed in meters per second, m s^{-1}, on the horizontal axis.

3.3.3 Computer Program

A computer program has been written which computes with inputs of height, z, and stability parameter, μ, the longitudinal, W_x, lateral, W_y, wind speeds and the wind gradients $\partial W_x/\partial z$ and $\partial W_y/\partial z$. The computer program also requires as input the friction velocity, u_*, the Coriolis parameter, f, and surface roughness, z_0. All velocities are input and output in m s^{-1} and lengths in meters, f, is introduced in s^{-1}.

This computer code can be used as a direct subroutine input to existing computer programs for flight simulators or computer programs of airplane motion in variable wind fields. The option of superimposing turbulence on the mean wind speed is available by appropriate specification of control variables. A complete description of the computer program is given in Appendix 3C.

3.4 Turbulence Model

A turbulence model has been developed for use with the neutral and stable boundary layer data which employs turbulence kinetic energy spectra developed by Kaimal [3-3], as shown in Figure 3-2. Kaimal gives the following functional form for the spectra.

$$\frac{n\phi_\alpha(n)}{\sigma_\alpha^2} = \frac{0.164\ \eta/\eta_0}{1 + 0.164(\eta/\eta_0)^{5/3}} \tag{3-5}$$

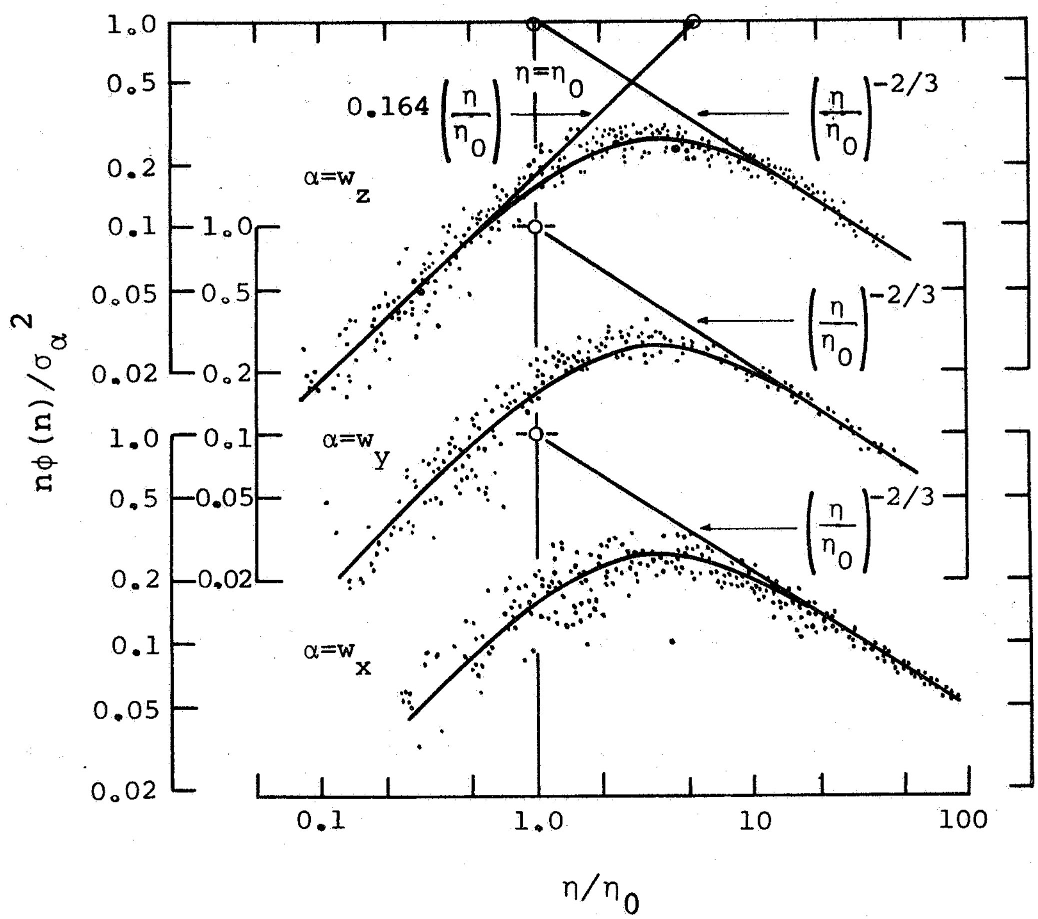

Figure 3-2 Comparison of Measured Turbulence Data with Equation 3-5 [3-3]

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$\phi_\alpha(n)$	Power spectral density distribution in α direction, $m^2\ s^{-1}$
n	Cyclic frequency, s^{-1}
σ_α	Turbulence intensity or root-mean-square fluctuation in α direction, $m\ s^{-1}$
η	Reduced frequency $nz/W_x(z)$
z	Height above ground, m
$W_x(z)$	Mean wind speed at the height z, $m\ s^{-1}$
α	Designates component of velocity fluctuation (either W_x, w_y or w_z)

The influence of atmospheric stability enters through the variable η_o which is a characteristic reduced frequency and is a function of Richardson's number as shown in Figure 3-3. These values of η_o are for the range $0.04 < Ri \leq 0.20$.

Values of η_o for the neutral boundary layer where Ri = 0 are recommended in Reference [3-4] as

$$(\eta_o)_{w_x} = 0.01444;\ (\eta_o)_{w_y} = 0.0265;\ (\eta_o)_{w_z} = 0.0962 \qquad (3\text{-}6)$$

Thus for the complete range of $0 \leq Ri \leq 0.2$ the approximate relationships are used in this report are

$$(\eta_o)_{w_x} = \begin{cases} 0.0144 & 0 \leq Ri < 0.029 \\ 0.5\ Ri & 0.029 \leq Ri \leq 0.2 \end{cases} \qquad (3\text{-}7)$$

$$(\eta_o)_{w_y} = \begin{cases} 0.0265 & 0 \leq Ri < 0.018 \\ 1.5\ Ri & 0.018 \leq Ri < 0.2 \end{cases} \qquad (3\text{-}8)$$

$$(\eta_o)_{w_z} = \begin{cases} 0.0962 & 0 \leq Ri < 0.035 \\ 2.8\ Ri & 0.035 \leq Ri < 0.2 \end{cases} \qquad (3\text{-}9)$$

The relationship between Ri and μ is

$$Ri = (\hat{z}\mu/\kappa)[1 + 4.5\ \hat{z}\mu/\kappa]^{-1} \qquad (3\text{-}10)$$

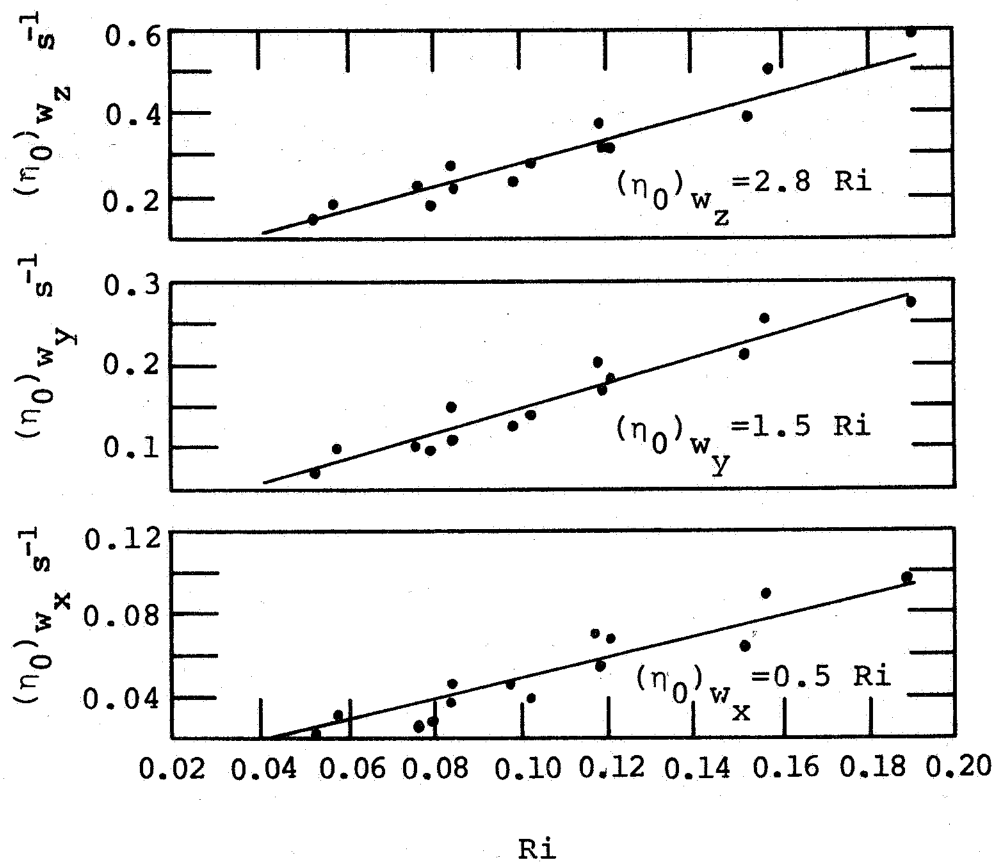

Figure 3-3 Correlation of η_0 with Richardson Number for Stable Boundary Layers

The turbulence spectra data of Kaimal [3-3] given above appear to be the most comprehensive presentation of atmospheric spectra associated with the stable boundary layer and are taken herein to represent the state of the art.

To utilize Equation 3-5 a value of turbulence intensity must be determined. Figure 3-4, taken from Reference [3-5], gives the turbulence intensity of the vertical wind speed component, σ_{w_x}, nondimensionalized with u_*, plotted as a function of nondimensional altitude, $\hat{z}\mu/\kappa$. For neutral conditions, $\hat{z}\mu/\kappa = 0$ and the ratio of vertical turbulence intensity, σ_{w_z}, to the friction velocity, u_*, becomes 1.3.

At $\hat{z}\mu/\kappa = 1.22$, the turbulence intensity vanishes as the atmospheric boundary layer becomes so stable that essentially laminar flow is achieved. In general, σ_{w_z}/u_* decreases with increasing stability.

A curve fit of Figure 3-4 between $0 \leq \hat{z}\mu/\kappa \leq 1.22$ is

$$\frac{\sigma_{w_z}}{u_{*o}} = \begin{cases} 1.3 - 0.13(\hat{z}\mu/\kappa)^{0.5} & 0 \leq \hat{z}\mu/\kappa \leq 1.0 \\ 6.49 - 5.32(\hat{z}\mu/\kappa) & 1.0 < \hat{z}\mu/\kappa \leq 1.22 \end{cases} \qquad (3\text{-}11)$$

The value of σ_{w_z} can thus be determined for given values of u_*, μ and $\hat{z}$.

No satisfactory mathematical description of how σ_{w_x} and σ_{w_y} vary with large scale surface features nor how they vary with atmospheric stability is available. Barr, et al. [3-5] propose that the ratio $\sigma_{w_x}/\sigma_{w_z}$ be treated as a function of altitude according to the following

$$\sigma_{w_x}/\sigma_{w_z} = \begin{cases} [0.177 + 0.832\ z/z_i]^{-0.4} & z < z_i \\ 1.0 & z > z_i \end{cases} \qquad (3\text{-}12)$$

z_i = 300 m or 1000 ft. Reference [3-5] also proposes that $\sigma_{w_y}/\sigma_{w_z} = \sigma_{w_x}/\sigma_{w_z}$. This relationship does not result in satisfactory agreement with Equation 3-5, however, and the relationship

$$\sigma_{w_y}/\sigma_{w_z} = \begin{cases} [0.583 + 0.417\ z/z_i]^{-0.8} & z < z_i \\ 1.0 & z > z_i \end{cases} \qquad (3\text{-}13)$$

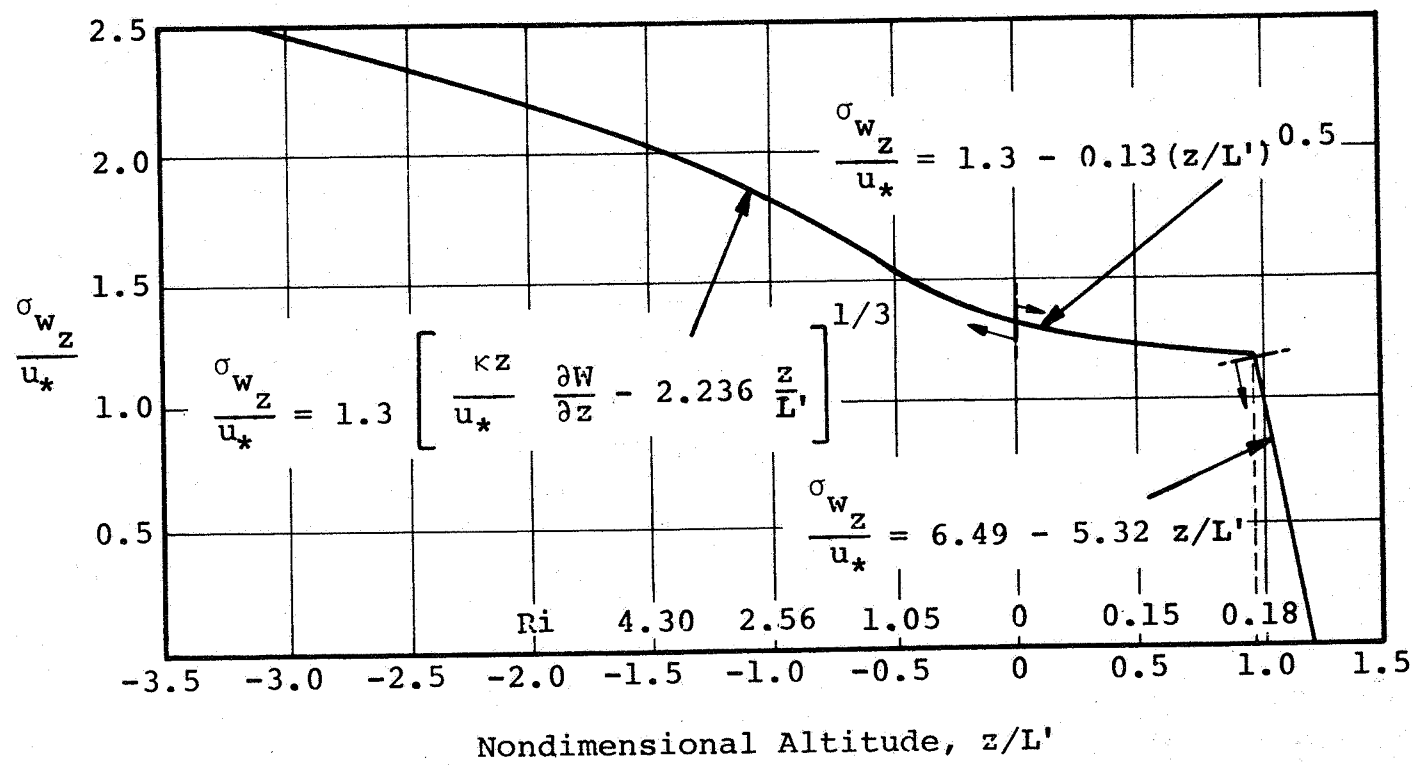

Figure 3-4 Vertical Turbulence Intensity

is proposed by Frost [3-4]. Equation 3-13 is developed identical to Equation 3-12 but assumes that σ_{w_y} is less than σ_{w_x} near the ground. The assumption is that for neutral conditions $\sigma_{w_x}/\sigma_{w_y}/\sigma_{w_z}$ = 2.6/2.0/1.3 which is consistent with a number of reported results.

Values of $\sigma_{w_x}/\sigma_{w_z}$ and $\sigma_{w_y}/\sigma_{w_z}$ are plotted in Figure 3-5 as a function of dimensionless height to facilitate computation of these values. Inspection of Equations 3-11, 3-12 and 3-13 show that for the neutral atmosphere

$$\sigma_{w_x} = 2.6\ u_*,\ \sigma_{w_y} = 2.0\ u_* \text{ and } \sigma_{w_z} = 1.3\ u_* \tag{3-14}$$

Figure 3-6 shows longitudinal turbulence spectra for varying degrees of stability. Turbulence in the atmosphere is observed to decrease with increasing stability. This is most evident at the low frequency range and is to be expected since the thermal effects which create stable boundary layers depress large scale turbulent motion. These spectra, however, are reported to be influenced by surface terrain features, particularly in the longitudinal and lateral components. No mathematical models which account for terrain effects are available. The spectra having been measured for relatively homogeneous terrain which is characteristic of the majority of airports should give a valid representation of most terminal areas. For airports located near unusual terrain features such as mountains or cliffs, fluctuations in the longitudinal and lateral components of the wind may, however, be higher than simulated by the proposed turbulence model.

The spectra represented by Equation 3-5 do not have a rational form and, consequently, are difficult to use in turbulence simulation schemes [3-6]. To overcome this difficulty, the spectral data in Figure 3-2 were adjusted to fit a modified Dryden spectrum having the functional form

$$\frac{n\phi(n)}{\sigma^2} = \frac{C_1 n/n_o}{1 + C_2(n/n_o)^2} \tag{3-15}$$

The constants C_1 and C_2 are adjusted such that the modified Dryden curve fits Kaimal's data [3-3]. Values of C_1 = 0.1580 and C_2 = 0.0694 were determined

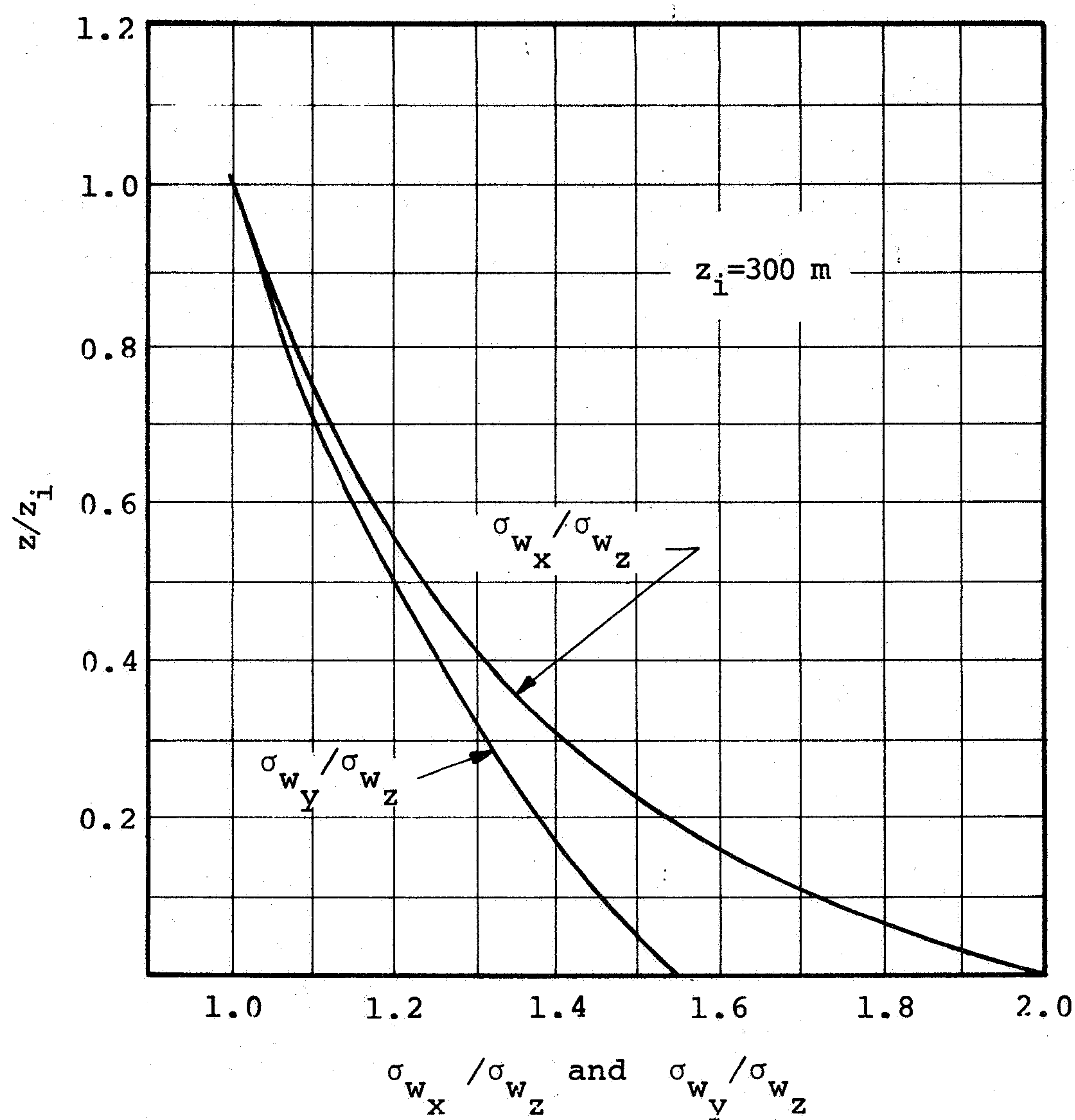

Figure 3-5 Longitudinal and Lateral Turbulence Intensity

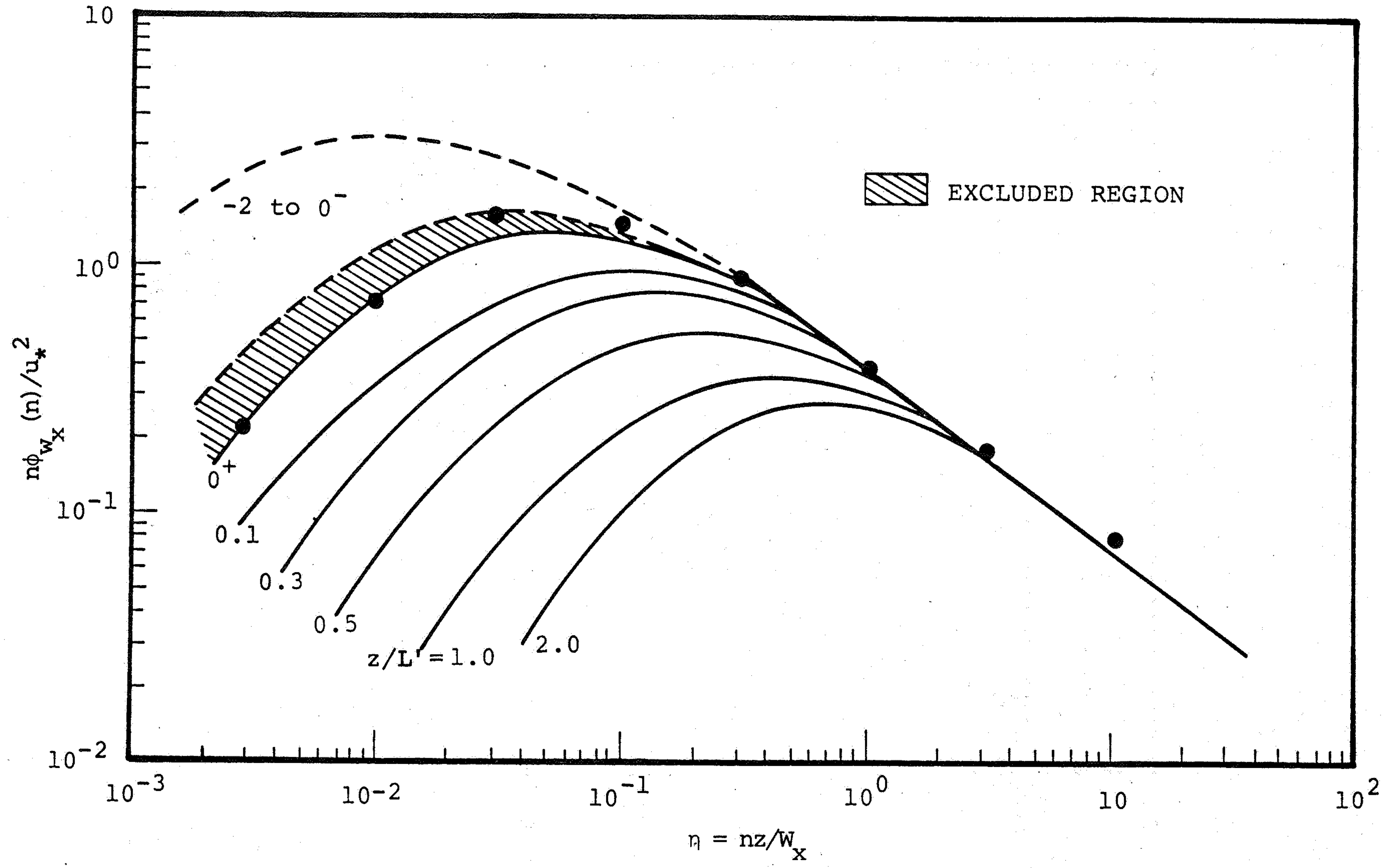

Figure 3-6 Influence of Stability on Turbulence Energy Spectrum

to give the best curve fit. Thus, the power spectral density function chosen for the turbulence simulation model

$$\frac{n\phi(n)}{\sigma_\alpha^2} = \frac{0.1580\ \eta/\eta_o}{1 + 0.0694(\eta/\eta_o)^2} \qquad (3\text{-}16)$$

Figure 3-7 compares the modified Dryden spectra with Equation 3-16. Although this curve fit does not provide a good representation of the higher frequency spectra, it does fit the data quite well in the lower frequency range which is expected to have the most significant influence on the flight of aircraft.

This turbulence model utilizing the turbulence spectra given by Equation 3-16 and the z transformation technique (see Neuman and Foster [3-7]) has been developed and can be coupled with the mean wind fields for the stable and neutral boundary layers to give a random fluctuating field. The model, however, is linear and results in a Gaussian distribution of the wind speeds in the atmosphere which introduces a small error into the simulation (see Reeves, et al. [3-6]).

To illustrate the influence of turbulent fluctuations on the velocity profile experienced by an aircraft during landing in a stable boundary layer, Figures 3-8 through 3-13 have been prepared. These figures illustrate stable boundary layer wind speed profiles seen by an aircraft on a 3° glide slope with turbulence, computed by the simulation technique, superimposed. The inertial aircraft velocity is 64 m s^{-1} which corresponds to a sink rate of 3.35 m s^{-1}. The time increment used in the turbulence simulation was taken as 0.15 sec which results in a turbulent fluctuation being superimposed at Δz increments of 0.35 m along the flight path. The figures show some interesting results relative to the stability of the boundary layer. In these figures, u_* has been held constant and μ is increased in sequential order. The first velocity profile (Figure 3-8) corresponds to the neutrally stable layer where μ is essentially zero. One observes that the aircraft encounters turbulence from the 500 m level to the ground and that the turning of the boundary layer is reasonably small after 100 m. The second figure (Figure 3-9) illustrates a somewhat higher level of stability, $\mu = 25$. The longitudinal wind speed is larger because, as noted earlier, the computed

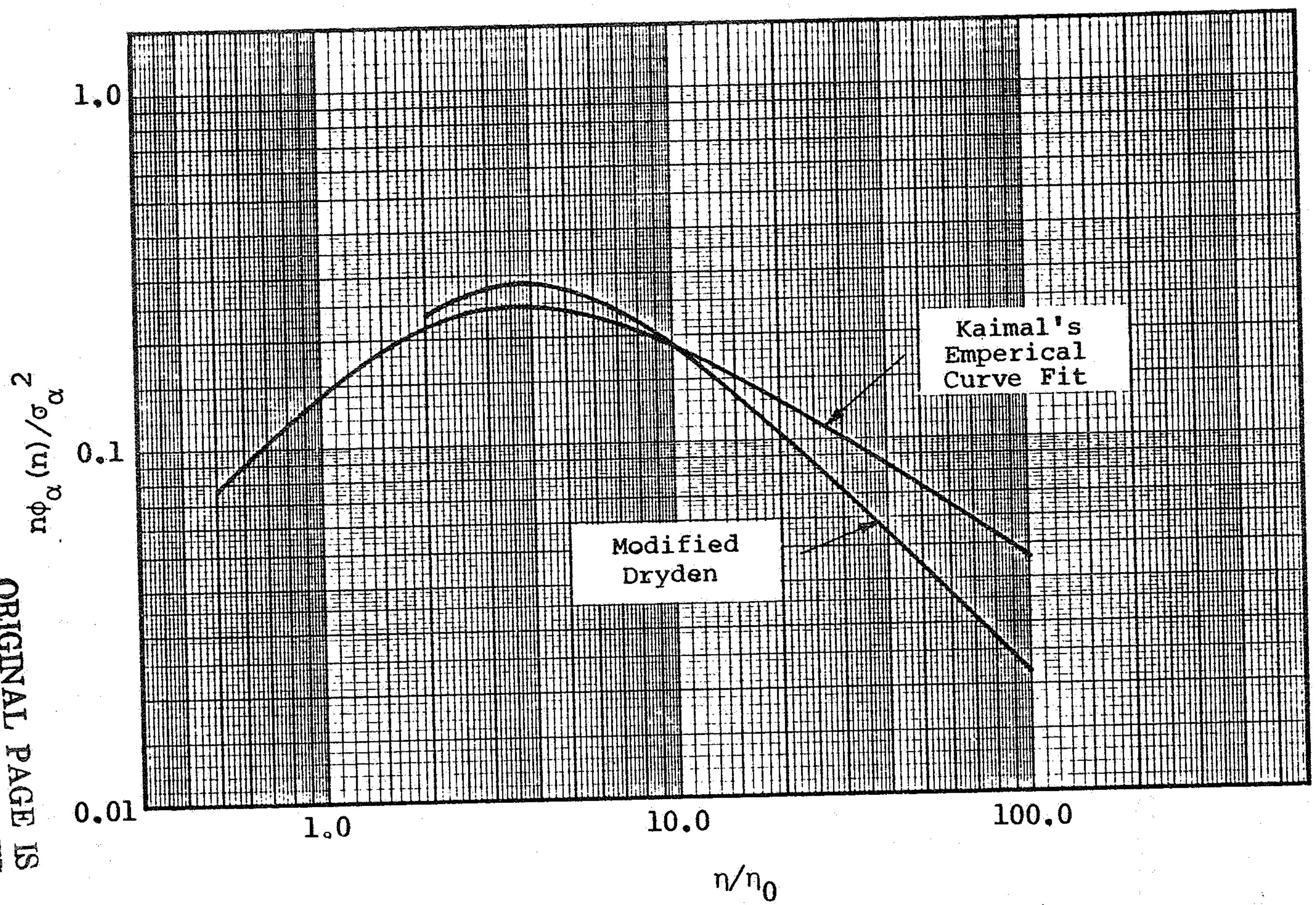

Figure 3-7 Comparison of the Modified Dryden Spectrum with Kaimal's Emperical Curve Fit [3-3]

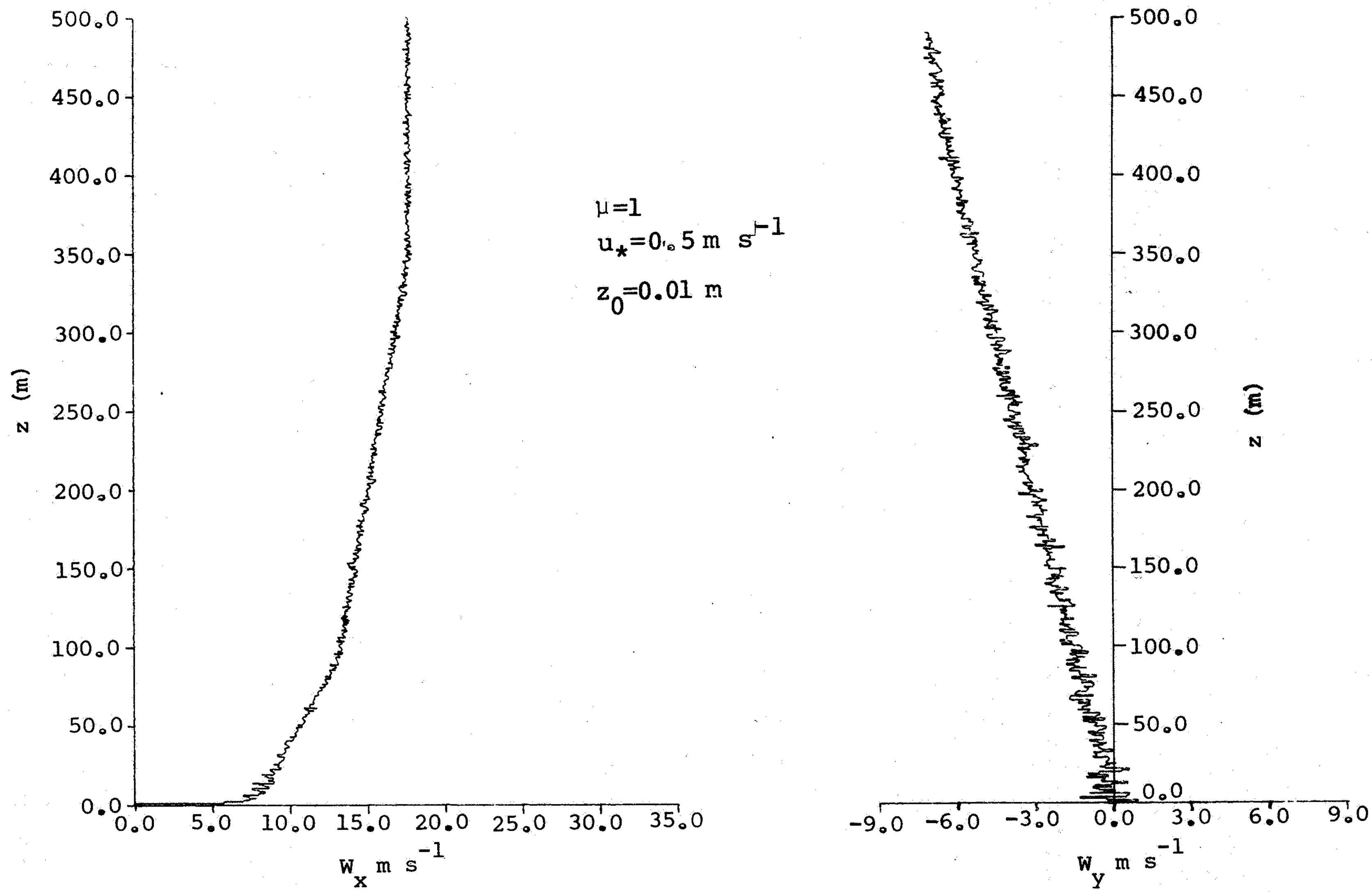

Figure 3-8 Near Neutral Boundary Layer with Turbulence Superimposed

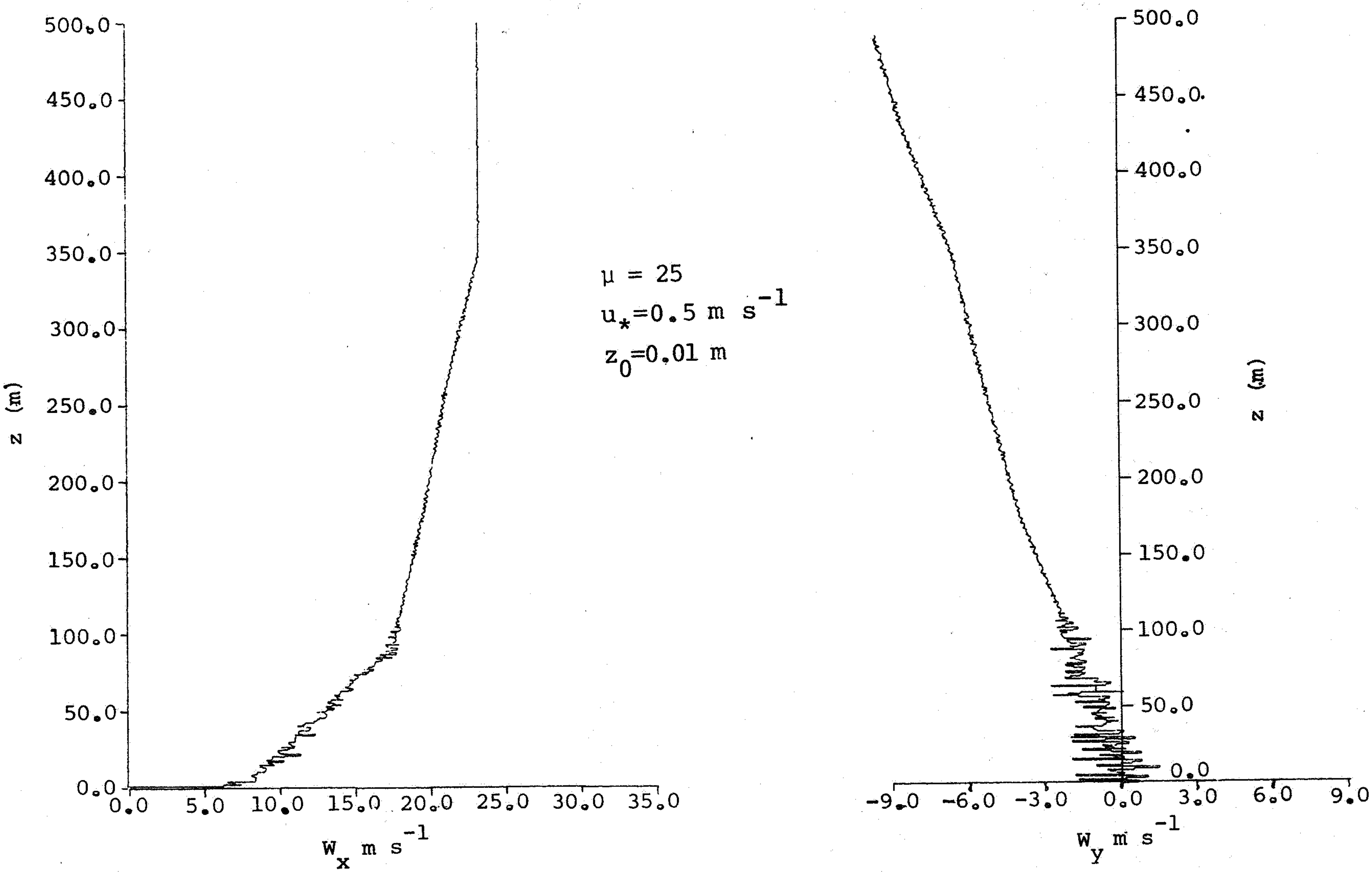

Figure 3-9 Stable Boundary Layer with Turbulence Superimposed

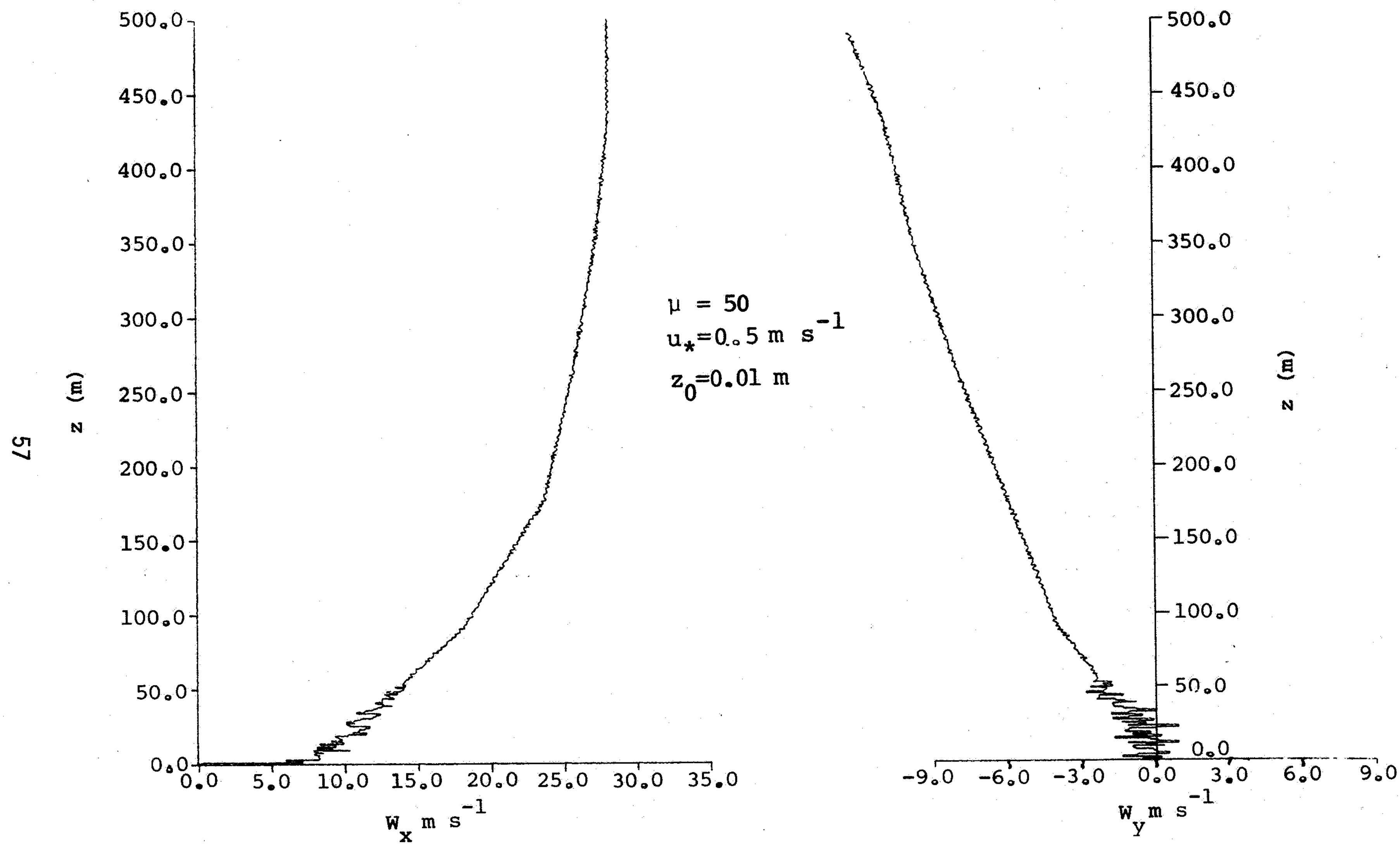

Figure 3-10 Stable Boundary Layer with Turbulence Superimposed

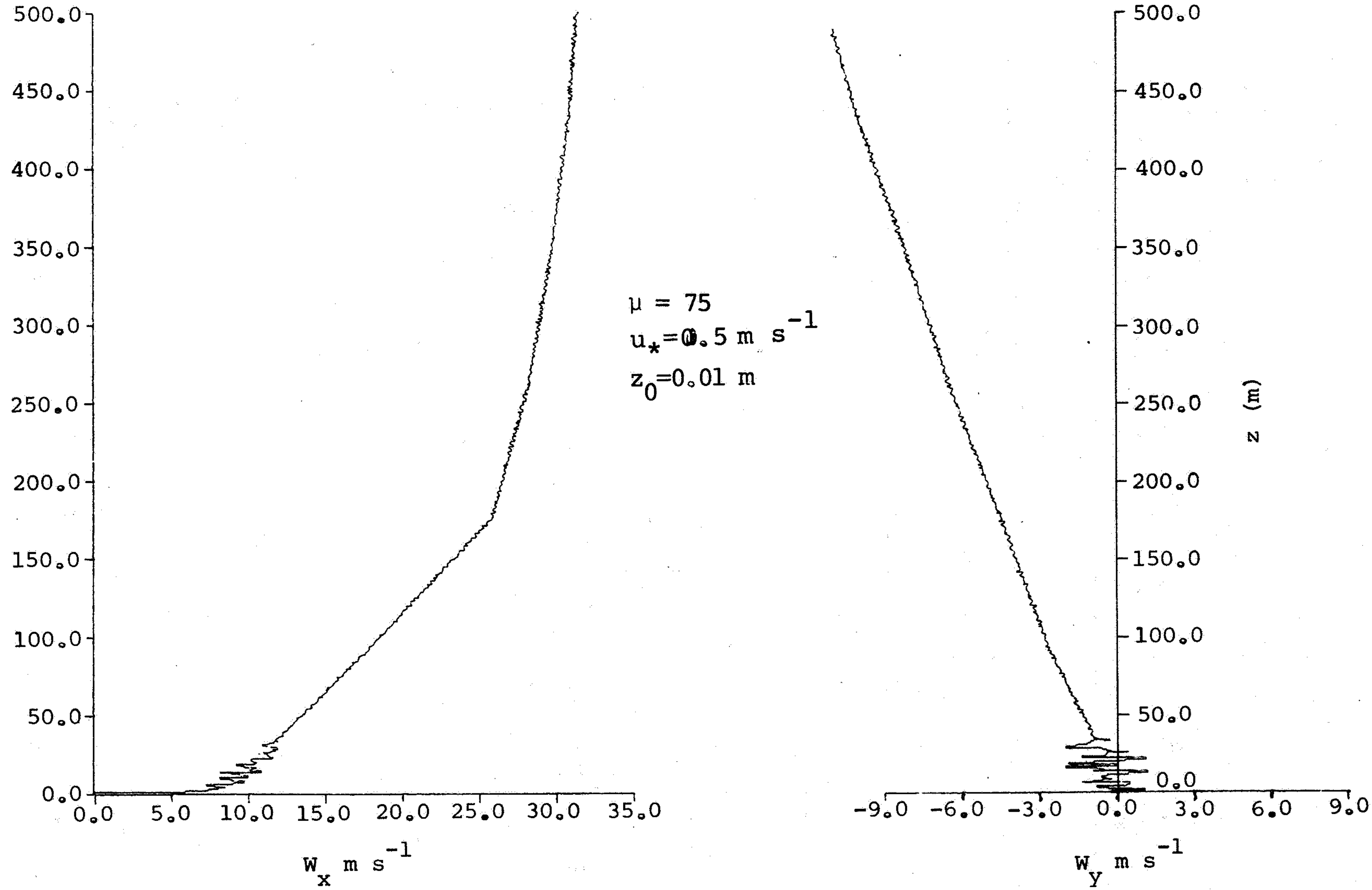

Figure 3-11 Stable Boundary Layer with Turbulence Superimposed

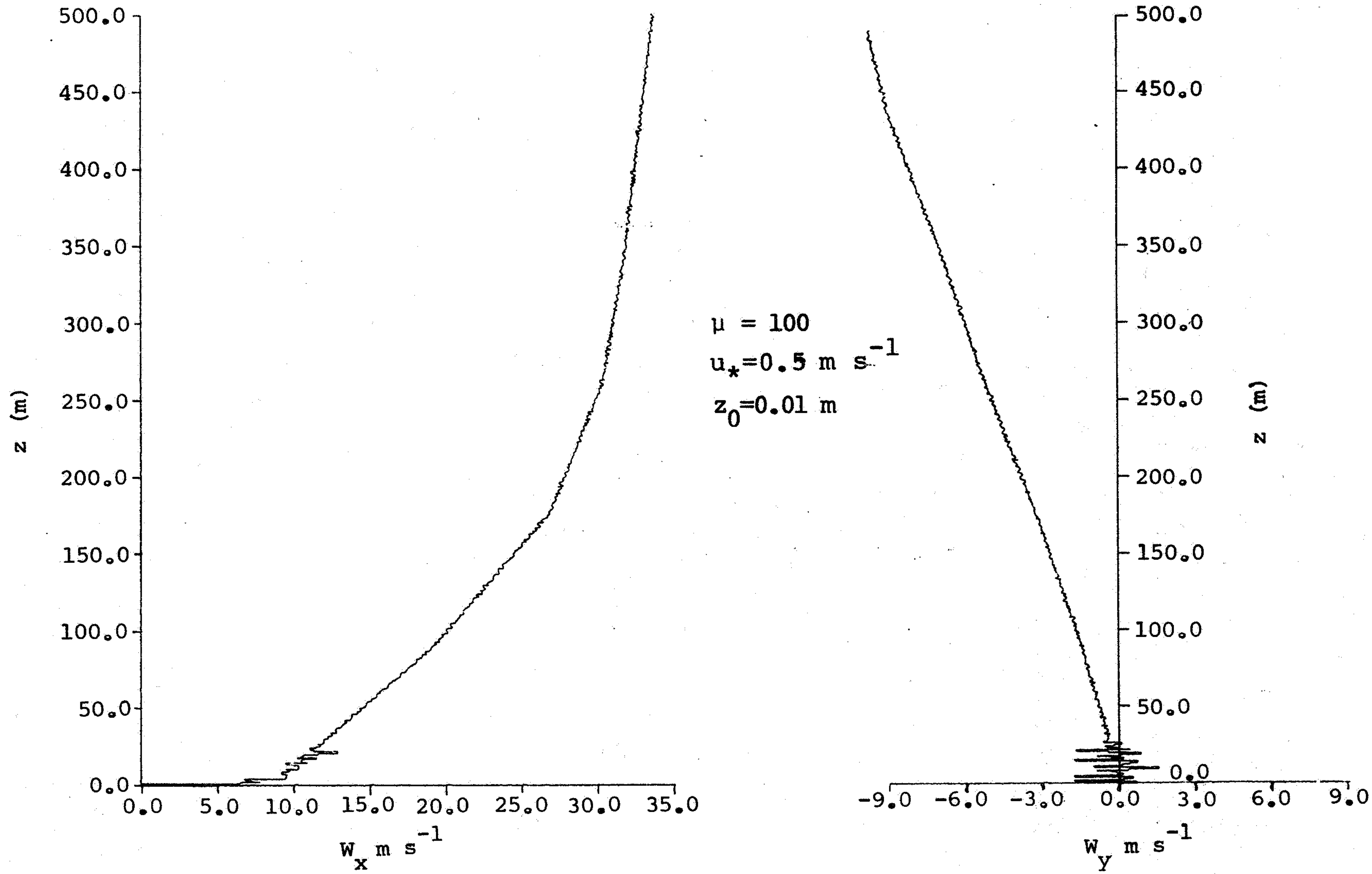

Figure 3-12 Stable Boundary Layer with Turbulence Superimposed

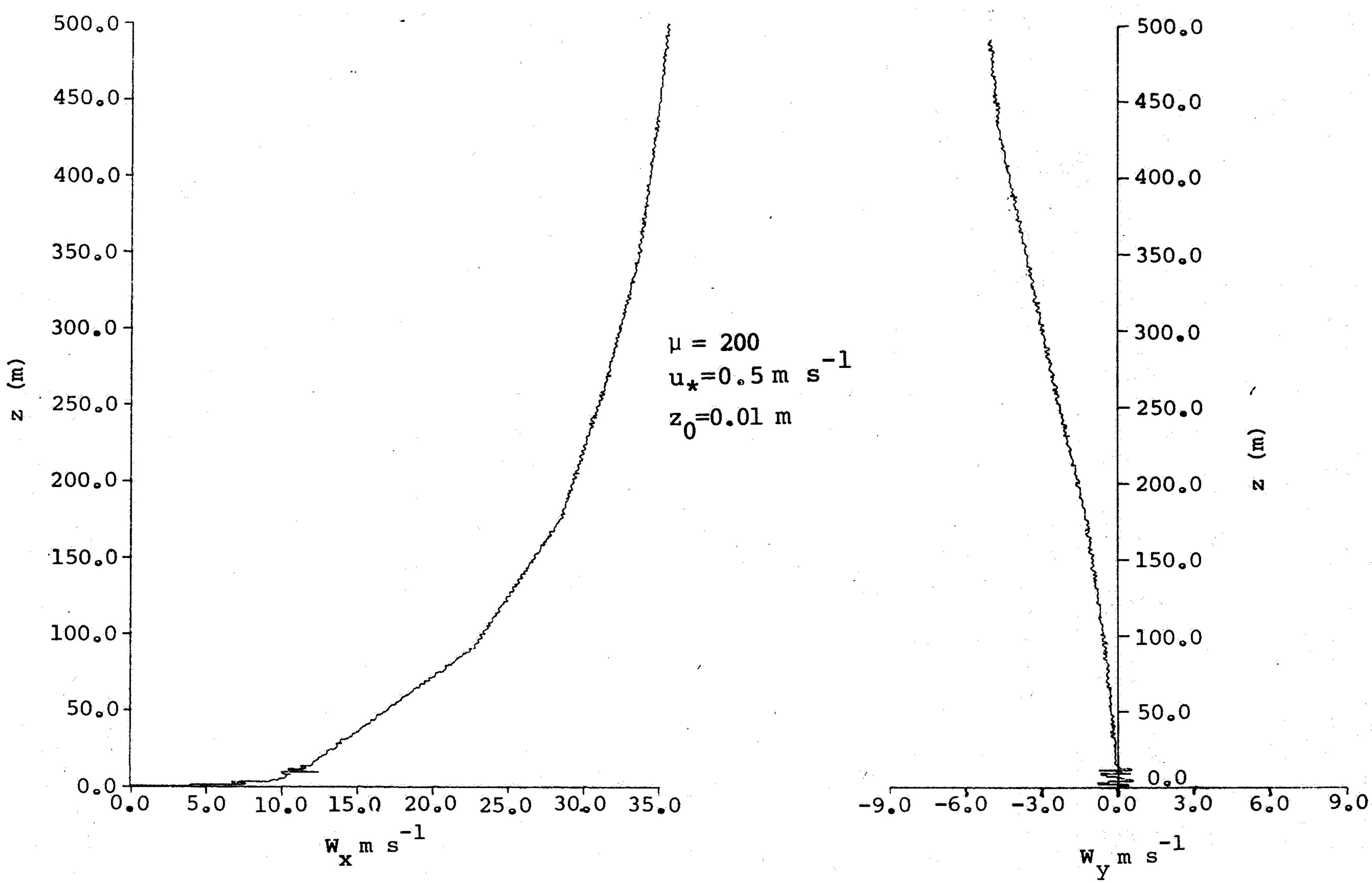

Figure 3-13 Stable Boundary Layer with Turbulence Superimposed

profiles are based on the same friction velocity, u_*, and surface roughness, z_0. The interesting feature of this figure is that at large values of z, i.e., where z/L' is large, the mechanical turbulence is damped out by buoyancy induced turbulence, however, as z/L' becomes small due to the aircraft approaching the ground, the situation is reached where the atmospheric boundary layer returns to a neutral condition and mechanical turbulence dominates the buoyancy induced turbulence. In Figure 3-9 this occurs at approximately 125 m. The airplane thus flies from a region of rather quiet flow to a sudden and rapidly increasing turbulent intensity. The turbulence intensity becomes larger as μ increases, however, this is not due to the effects of stability but due to higher mean velocities resulting from a constant u_*. For consecutive figures, as the stability of the boundary layer increases one observes that the transition from the essentially laminar flow to the highly turbulent region approaches lower and lower levels. It should also be noted from this sequence of figures that the strongest directional shear occurs at intermediate values of μ, whereas, the strongest linear shear occurs at the larger values of μ.

An alternate way of computing the profiles would be to assign the same wind speed at a certain level and adjust u_* accordingly. Physically this corresponds to conditions encountered at an airport where the wind speed measured with an anemometer at a fixed height, say, at the 10 m level would record identical values but the wind shear would be appreciably different due to the associated stability conditions. Figures 3-14 through 3-19 show computed profiles having a common value of 10 m s^{-1} wind speed at the 10 m level. The value of u_* used in the computation is related to the stability parameter, μ, by

$$u_* = 0.58 - 0.0016\ \mu$$

The same characteristics of the wind speed profiles are observed, however, the higher wind speeds now occur at intermediate values of μ rather than at the higher values as in the sequence of Figures 3-8 through 3-13. In turn, one observes that the directional shear is also largest at intermediate values of μ which is in correspondence with the former sequence of figures.

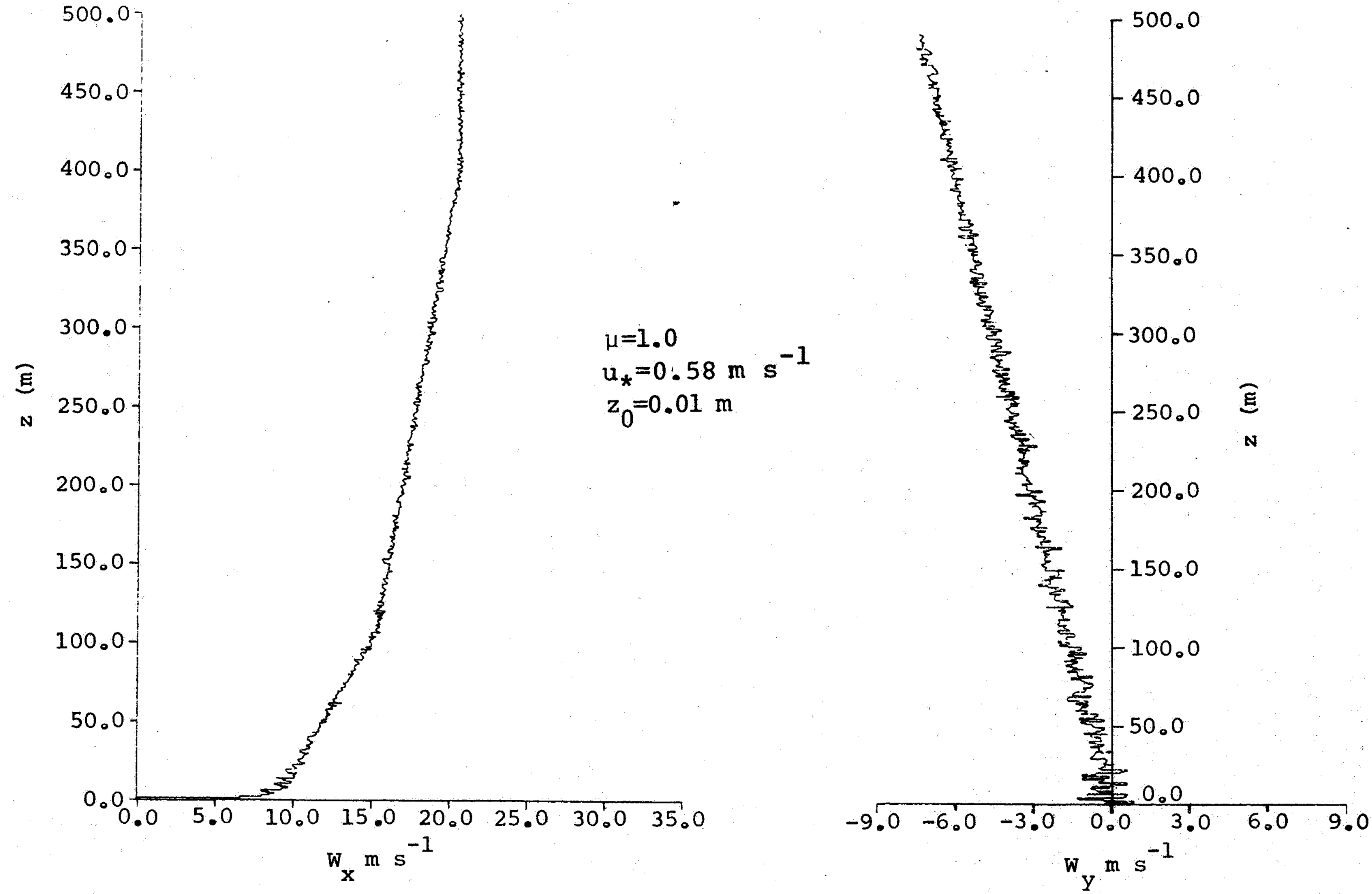

Figure 3-14 Near Neutral Boundary Layer with Turbulence Superimposed

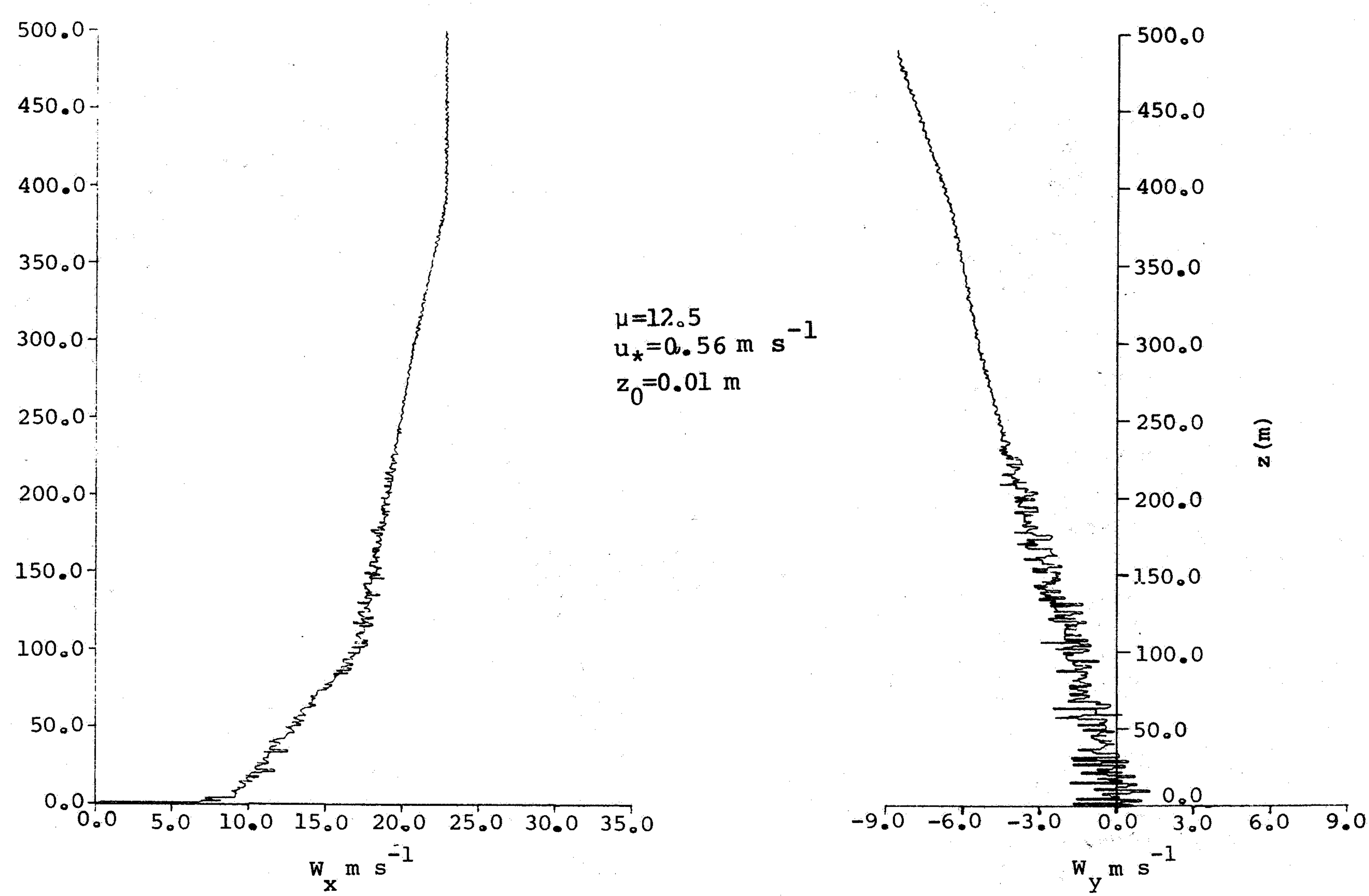

Figure 3-15. Stable Boundary Layer with Turbulence Superimposed

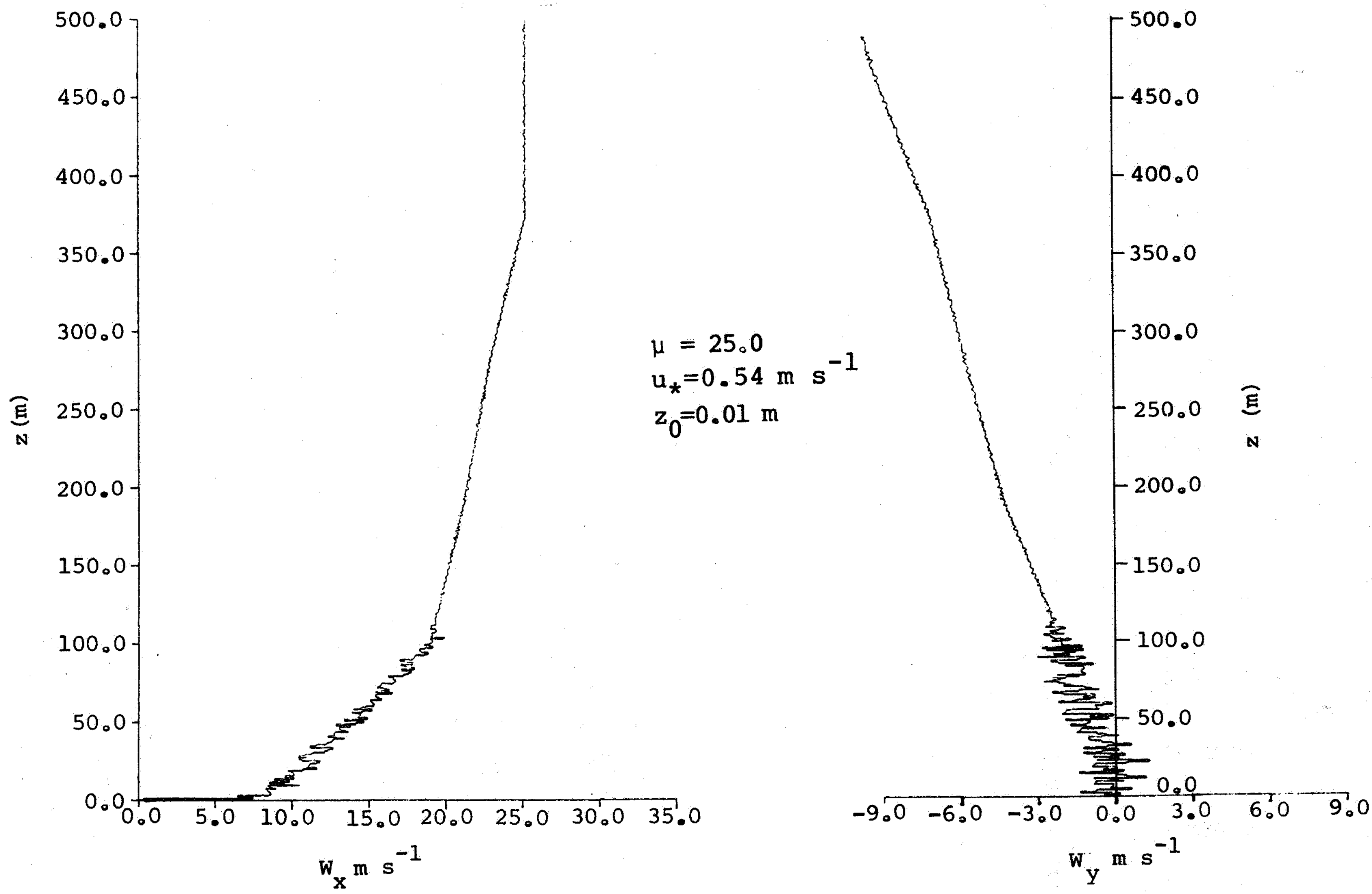

Figure 3-16 Stable Boundary Layer with Turbulence Superimposed

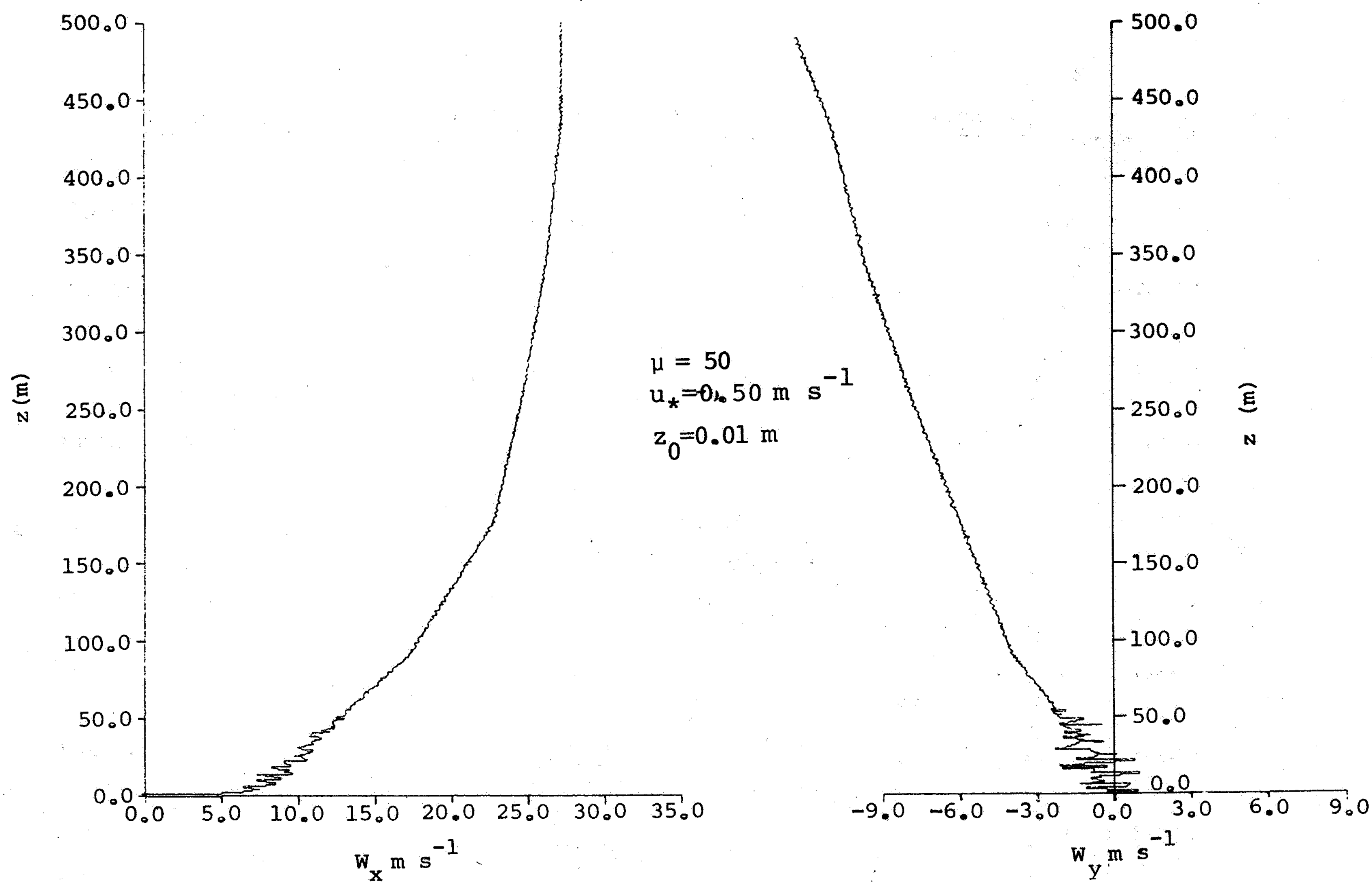

Figure 3-17 Stable Boundary Layer with Turbulence Superimposed

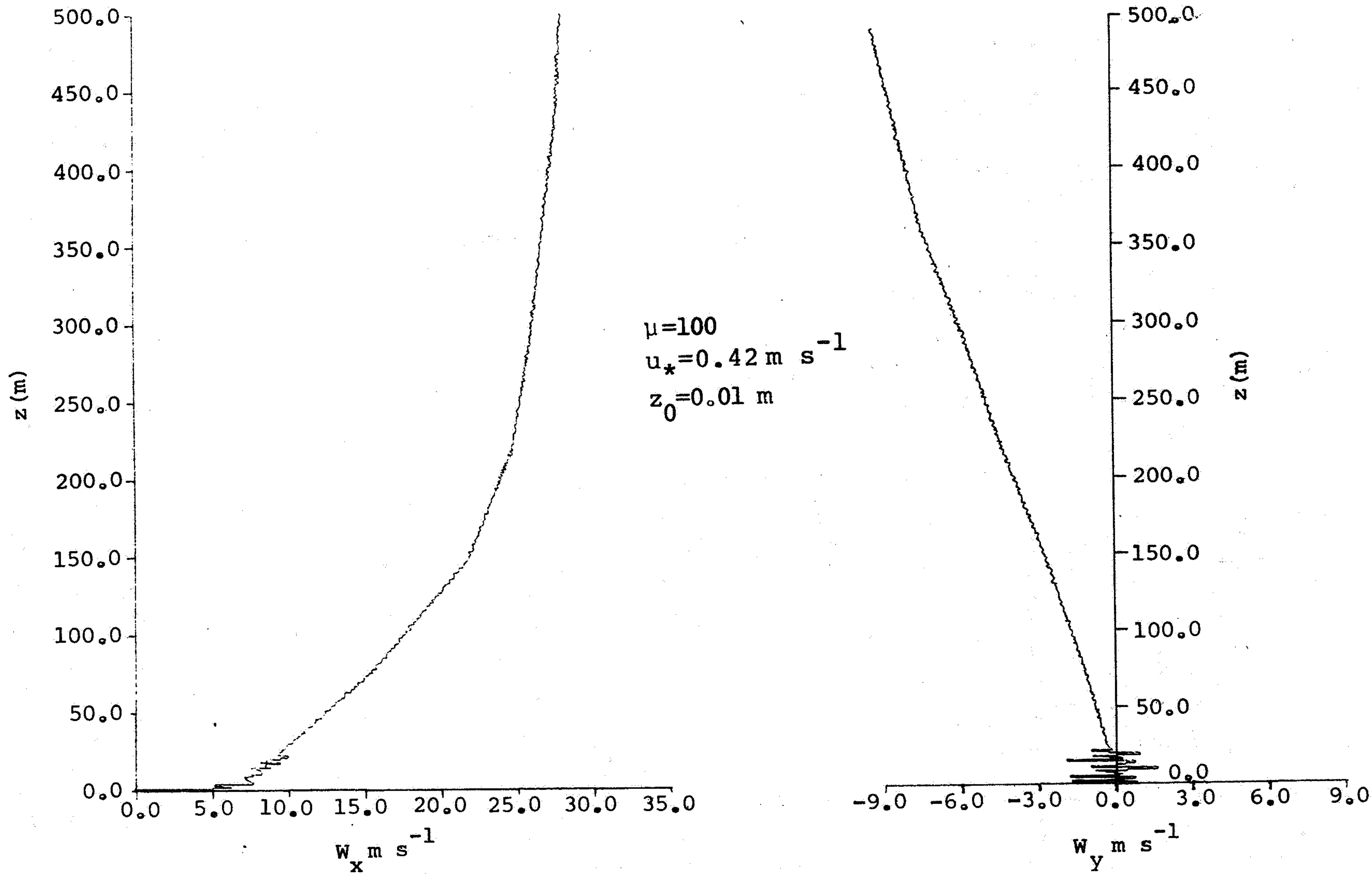

Figure 3-18 Stable Boundary Layer with Turbulence Superimposed

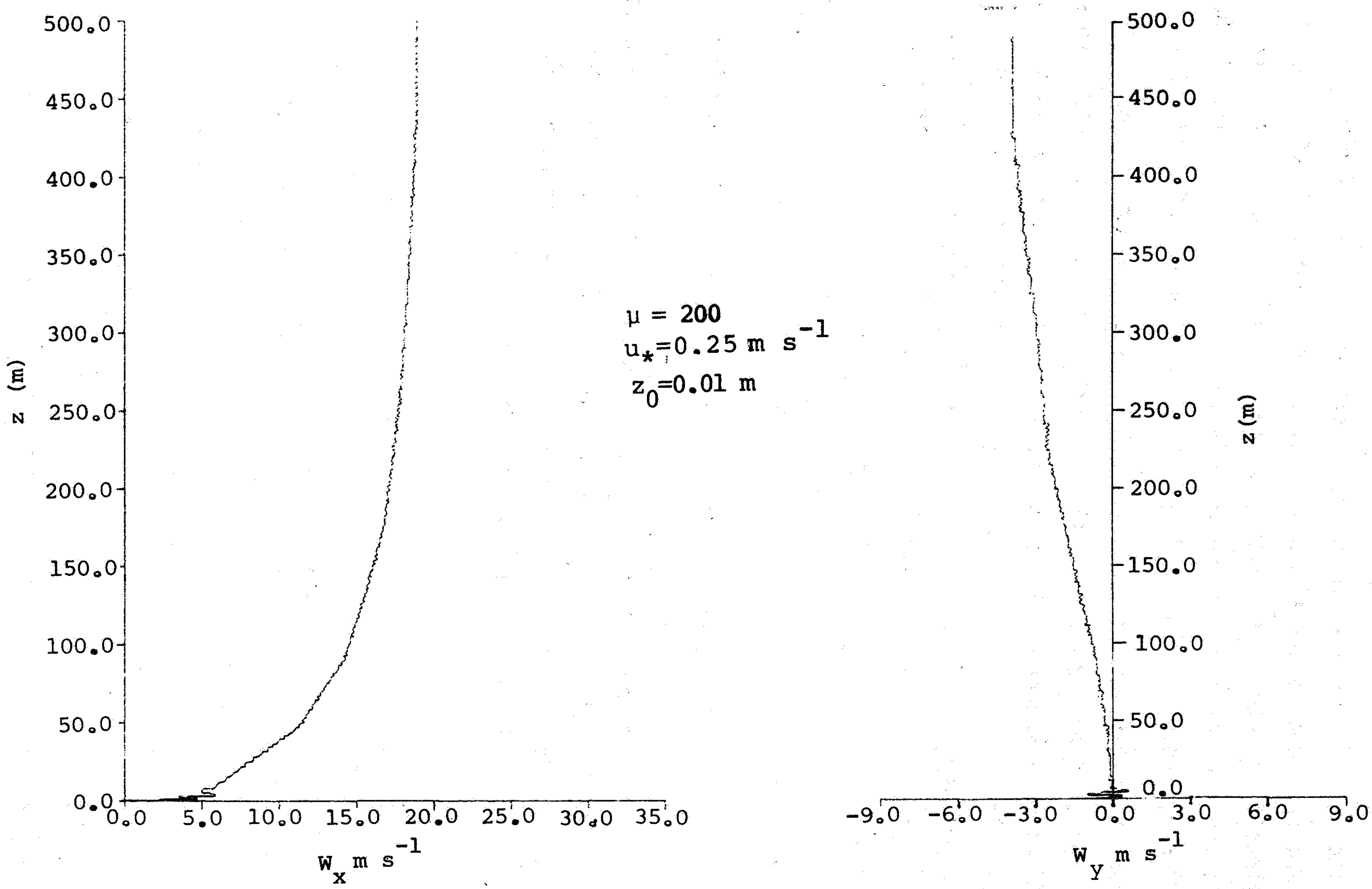

Figure 3-19 Stable Boundary Layer with Turbulence Superimposed

3.5 Statistical Model Relative to Risk of Exceedance

The wind shear associated with the stable and neutral boundary layers are dependent upon the variables, μ and u_*, or the mean wind speed, W_x, since they are directly related. A statistical description of these two parameters will enable the user of the wind shear model to provide an estimate of the probability and frequency of exceeding a prescribed value of wind shear.

In order to establish this statistical description some estimate of the probability of a given stability condition occurring simultaneously with a given value of u_* is needed. An approximate analysis to achieve this goal is proposed as follows. From statistical theory the probability of μ and u_* occurring simultaneously is equal to the probability of μ given u_*, $P(\mu \geq \mu_p/u_*)$, times the probability of u_*, $P(u_* \geq u_{*p})$, [3-8]. This is referred to as a conditional probability.

$$P(\mu \geq \mu_p;\ u_* \geq u_{*p}) = P(\mu \geq \mu_p/u_*)\ P(u_* \geq u_{*p}) \tag{3-17}$$

The probability of μ given a wind speed, W_x, which can be directly related to u_*, has been estimated by Barr, et al. [3-5]. They give the probability of Richardson number, Ri, for a given wind speed, W_x, where both W_x and Ri are evaluated at 6.1 m, shown in Figure 3-20. Note that these curves are highly interpolated and based on only two sets of data. The Richardson number, Ri, is related to μ by the relationship

$$Ri = \begin{cases} \dfrac{\mu/u_*}{\kappa/zf + 4.5\ \mu/u_*} & 0 \leq Ri \leq 0.18 \\[2ex] 0.18\ \dfrac{zf\mu}{\kappa u_*} & Ri \geq 0.18 \end{cases} \tag{3-18}$$

and W_x is related to u_* and μ by

$$\frac{W_x}{u_*} = \begin{cases} \dfrac{1}{\kappa}\ \ell n\left(\dfrac{z}{z_o} + 1\right) + 4.5\ \dfrac{zf\mu}{\kappa^2} & 0 \leq Ri \leq 0.18 \\[2ex] \dfrac{1}{\kappa}\left\{\ell n\left(\dfrac{\kappa u_*}{f\mu z_o} + 1\right) + 4.5 + 5.5\ \ell n\left[\left(\dfrac{z}{z_o} + 1\right)\Big/\left(\dfrac{\kappa u_*}{z_o\mu f} + 1\right)\right]\right\} & Ri \geq 0.18 \end{cases} \tag{3-19}$$

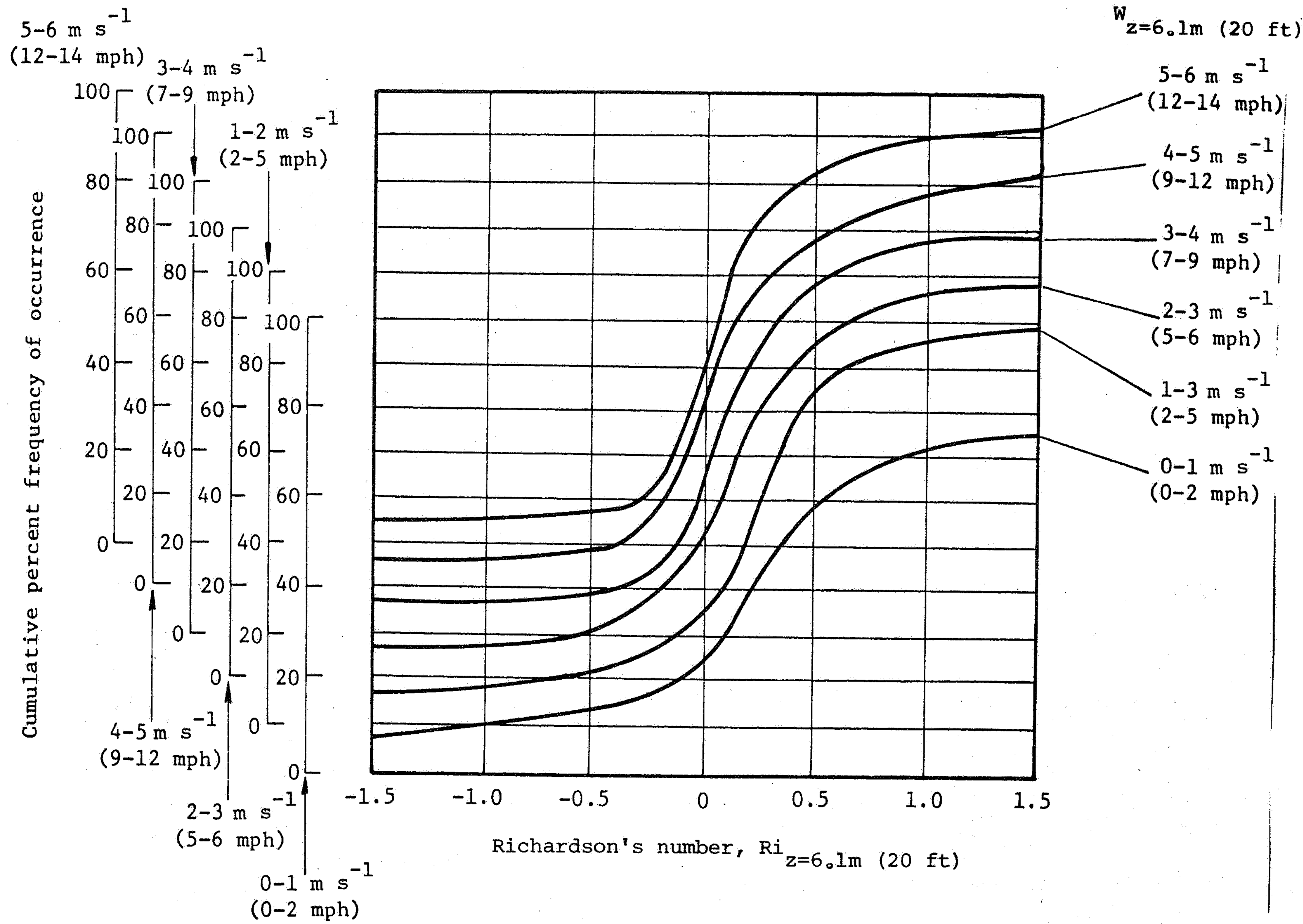

Figure 3-20(a) Cumulative Percent Frequency of Occurrence of Ri at Given Wind Speeds, 0 to 6 m s^{-1} (0 to 14 mph)

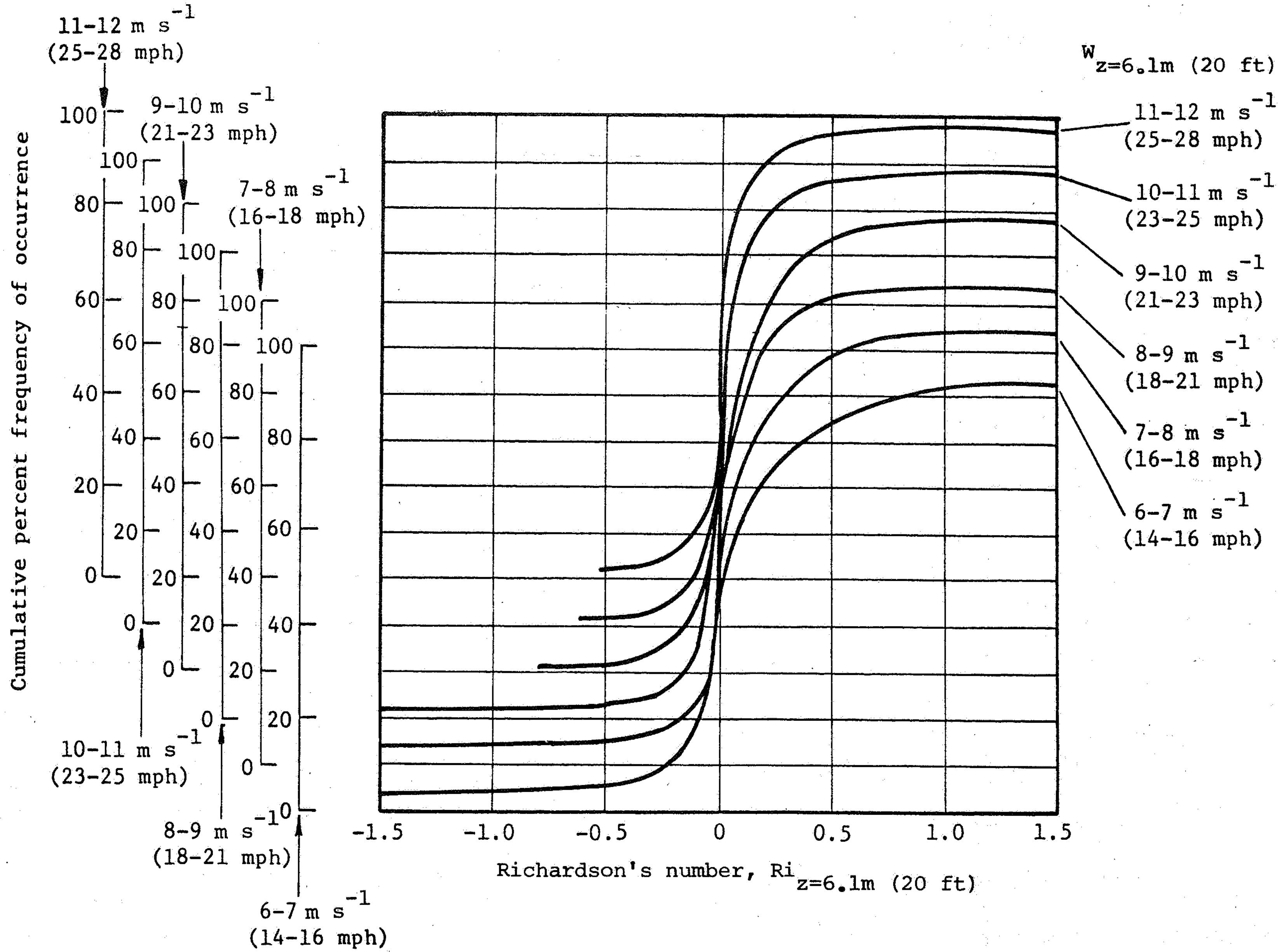

Figure 3-20(b) Cumulative Percent Frequency of Occurrence of Ri at Given Wind Speeds, 6 to 12 m s^{-1} (14 to 28 mph)

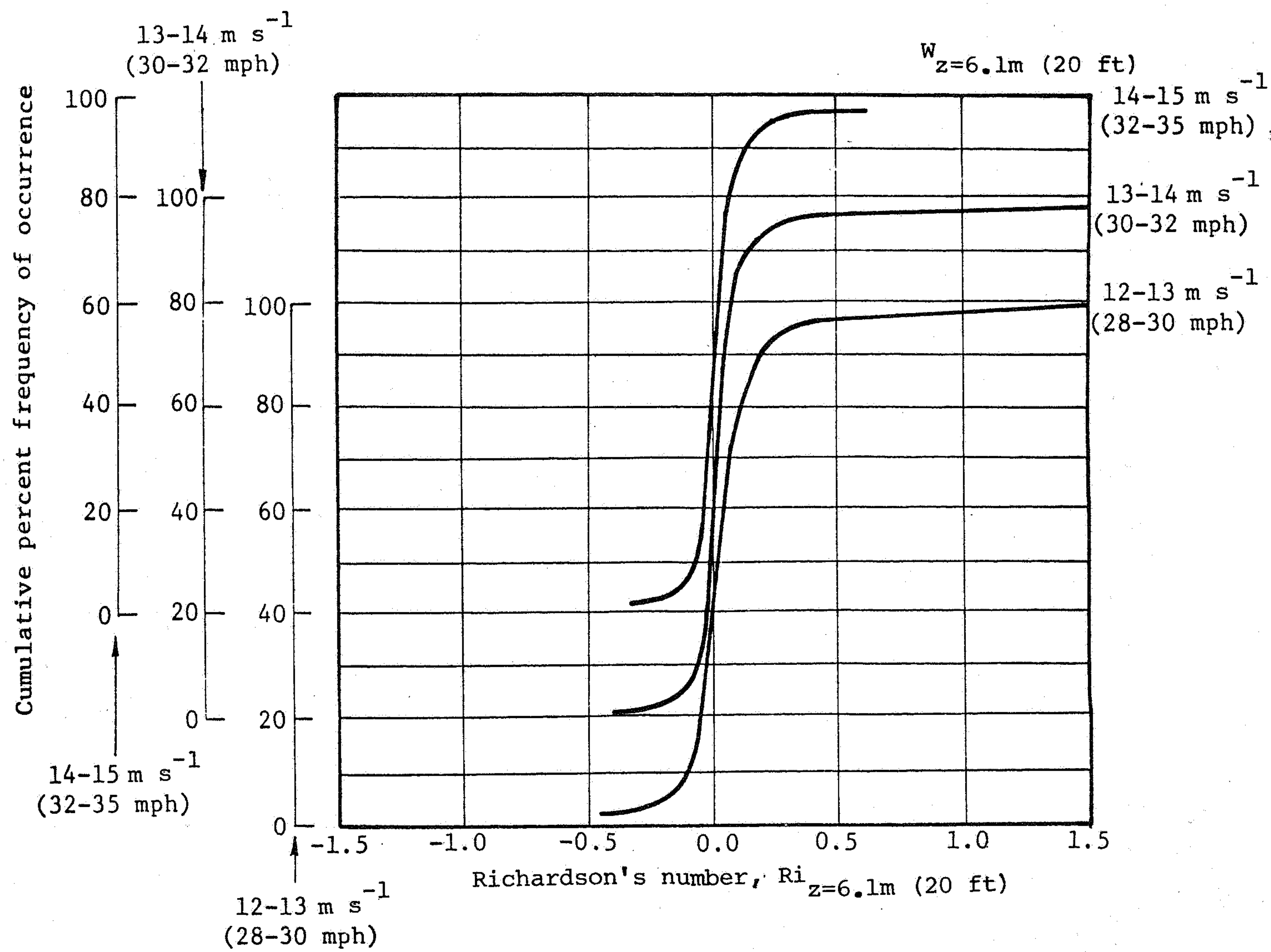

Figure 3-20(c) Cumulative Percent Frequency of Occurrence of Ri at Given Wind Speeds, 12 to 15 m s^{-1} (28 to 32 mph)

Assigning values of $z = 6.1$ m, $z_0 = 0.01$ m, $f = 10^{-4}\ s^{-1}$, $\kappa = 0.4$, Equations 3-18 and 3-19 have been plotted in Figures 3-21 and 3-22 for convenient reference.

Using the above results the designer may select a value of μ and a value of u_* which gives a wind shear condition in which he is interested. The probability of μ given u_* is then obtained directly from the figure.

The probability of u_* can be determined from the distribution of mean wind speeds given by Frost [3-4] as interpreted from Justus, et al. [3-9]. This reference shows that the probability of a mean wind speed greater than a prescribed value W_p occurring during the year is described by a Rayleigh distribution, i.e.,

$$P(W \geq W_p) = e^{-(W_p/c)^2} \tag{3-20}$$

Reference [3-4] shows that this equation is a general representation of wind speeds measured at 138 airport sites throughout the United States where an average value of the scale factor, c, is $4\ m\ s^{-1} \pm 0.9\ m\ s^{-1}$. Since u_* is related to mean wind speed by Equation 3-19, the probability of u_* is directly related to the probability of W_x.

With the information provided above, the user of the neutral and stable boundary layer wind shear model can estimate what the probability of a given wind shear occurring over an expected lifetime is by utilizing the probability of μ given u_* from Figure 3-20 and multiplying that by the probability of u_* given by Equation 3-19. To illustrate the use of the above model, consider the following example. A user wishes to determine the probability of μ being equal to 200 given that u_* is equal to $0.5\ m\ s^{-1}$. From Figure 3-21 find Ri = 0.164 corresponding to $\mu = 200$ and $u_* = 0.5\ m\ s^{-1}$, i.e., $\mu/u_* = 400$. From Figure 3-22 determine $W_x/u_* = 23$ and therefore $W_x = 11.5\ m\ s^{-1}$ for the given values of u_* and μ. From Figure 3-20 the probability of Ri $\geq$ to 0.16 at $11.5\ m\ s^{-1}$ is $1.0 - P(Ri \geq 0.16;\ W_x = 11.5\ m\ s^{-1}) = 0.12$. From Equation 3-20 the probability of $W_x \geq 11.5\ m\ s^{-1}$ is $P(W_x \geq 11.5\ m\ s^{-1}) = 0.0003$. The probability of both $\mu \geq 200$ and $W_x \geq 11.5$ occurring in a given year is from Equation 3-17 equal to 0.003%.

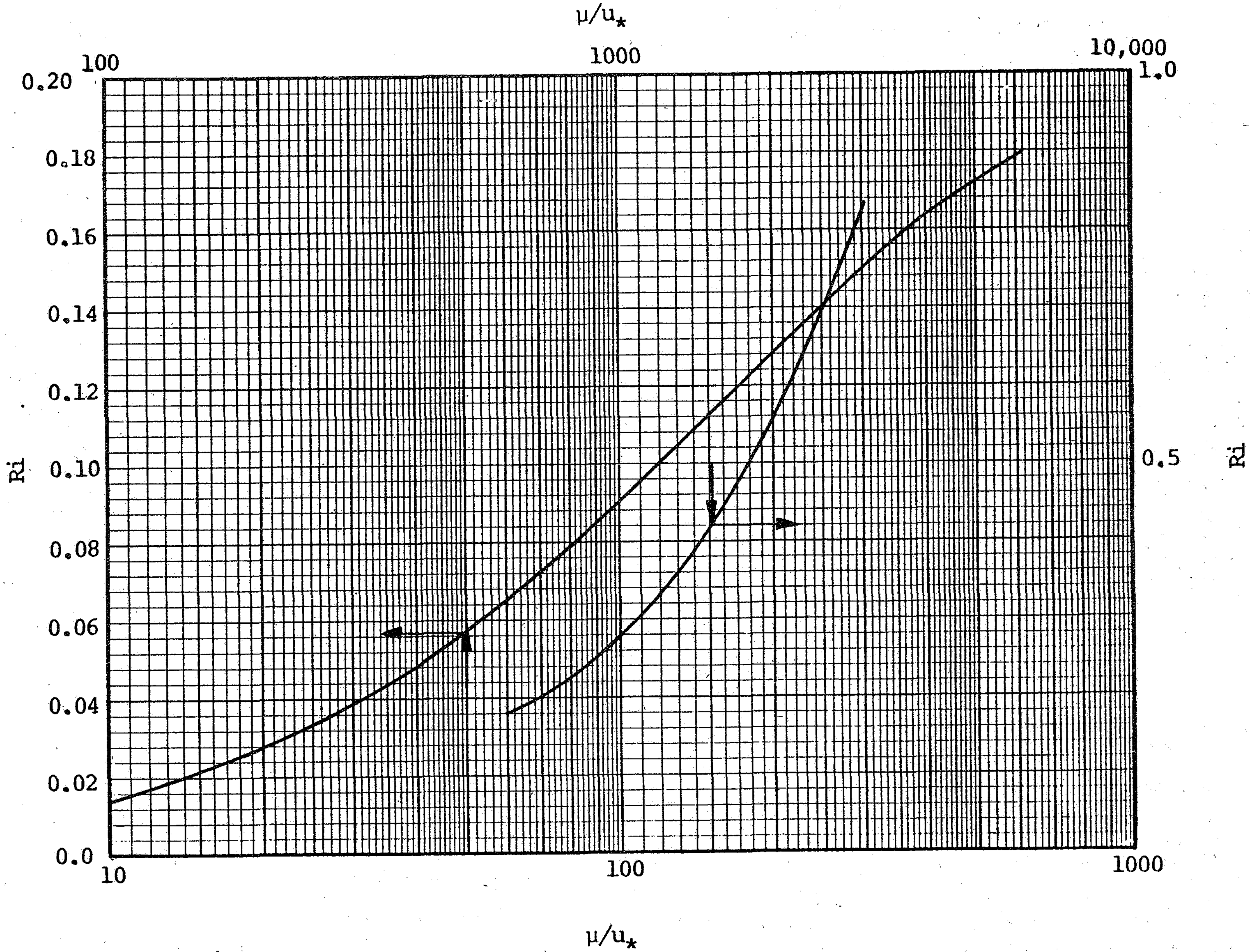

Figure 3-21 Variation of Ri with μ/u_* at z=6.1 m

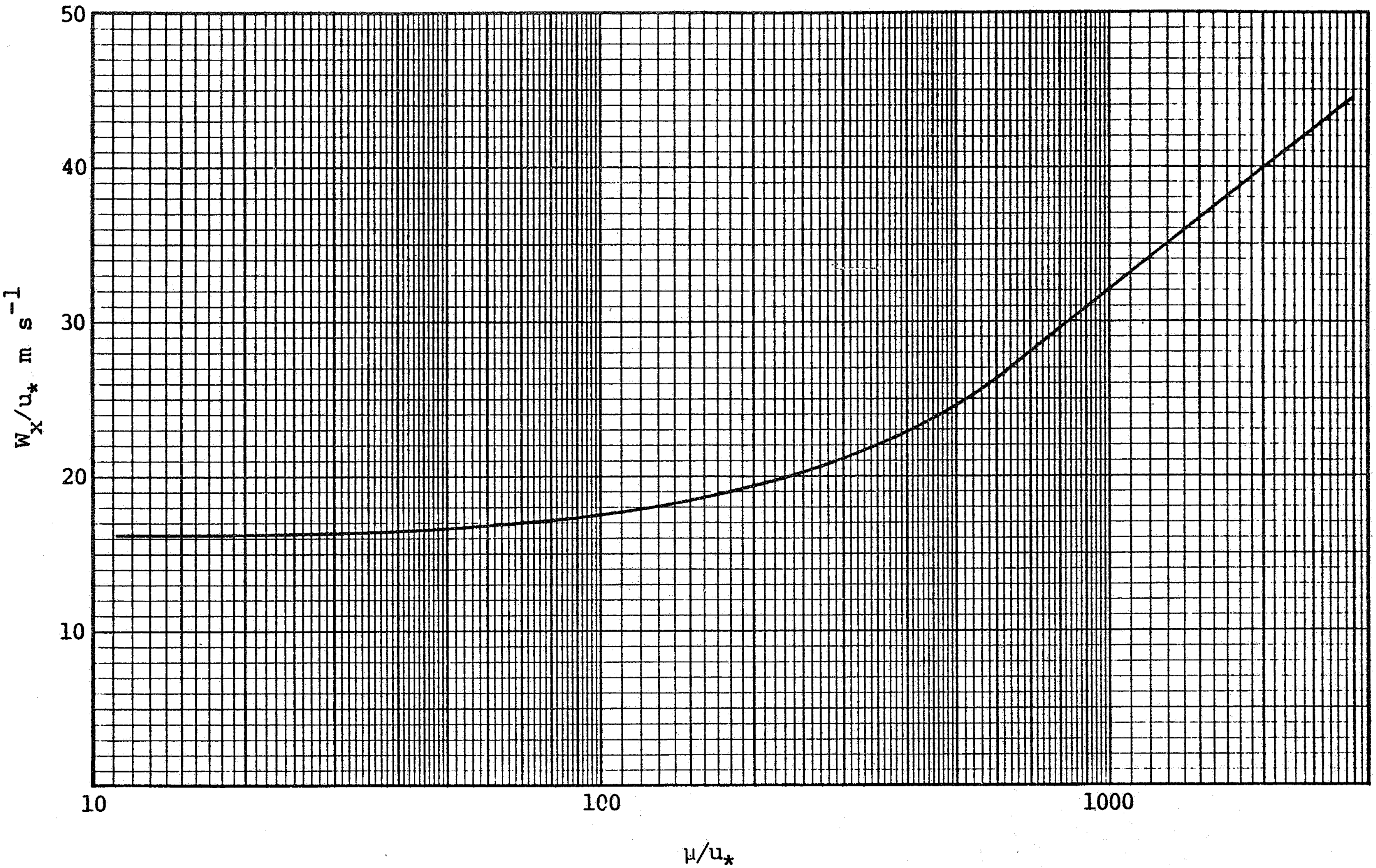

Figure 3-22 Variation of Wind Speed at $z = 6.1$ m with μ/u_* ($z_0 = 0.01$ m)

To establish the risk of exceeding a prescribed wind shear in a given period of time we proceed as follows. The probability, p, that μ will be exceeded in any one year is related to the return period T by the relationship Tp = 1. The probability that a value less than or equal to μ will occur in one year is q = 1 - p. In a period of N years the probability Q that a value less than or equal to μ will occur is

$$Q = q^N \tag{3-21}$$

The probability or risk that a value greater than μ will occur at least once in a period of N years is

$$\begin{aligned} P &= 1 - q^N \\ &= 1 - (1 - p)^N \end{aligned} \tag{3-22}$$

Hence continuing the foregoing example, the probability that $\mu = 200$ and $u_* = 0.5 \text{ m s}^{-1}$ will occur at least once in a period of 25 years is from Equation 3-22 equal to 3.4%.

To give the reader some feel for the nature of the wind shear associated with a given probability of occurrence, Table 3-1 has been prepared. This table gives the risk of exceedance associated with each of the wind shear conditions depicted in Figures 3-8 through 3-18.

3.6 Application of Wind Shear Models for Neutral and Stable Boundary Layers

Application of the wind shear model for the neutral and stable boundary layer proceeds by first selecting stability conditions for which the simulation is to be carried out. The parameters required are the stability parameter, μ, the friction velocity, u_*, and the surface roughness, z_0. The rule-of-thumb for the effect of these individual parameters is that high values of u_*, μ and z_0 all result in larger linear shear. On the other hand, intermediate values of μ, say, on the order of 50, give the largest directional shear within the lower 500 m of the atmospheric boundary layer. Inspection of Figures 3-8 and 3-9 clearly illustrate this.

TABLE 3-1

RISK OF EXCEEDANCE ASSOCIATED WITH WIND SPEED PROFILES SHOWN IN FIGURES 3-8 THROUGH 3-19

u_*	μ	Ri	W_x	$P(W_x)$	$P(Ri/W_x)$	$P(Ri \& W_x)$	Risk of Exceedance in 25 Yrs.
0.50	200	0.18	13.64	8.85×10^{-6}	0.70	6.2×10^{-5}	0.16%
0.50	150	0.17	12.24	8.61×10^{-5}	0.74	6.4×10^{-5}	0.16%
0.50	100	0.15	10.83	6.54×10^{-4}	0.65	4.3×10^{-4}	1.07%
0.50	75	0.14	10.13	1.64×10^{-3}	0.64	1.0×10^{-3}	2.47%
0.50	50	0.12	9.43	3.88×10^{-3}	0.58	2.3×10^{-3}	5.59%
0.50	25	0.080	8.72	8.61×10^{-3}	0.56	4.8×10^{-3}	11.33%
0.50	1	0.005	8.05	17.47×10^{-3}	0.42	7.3×10^{-3}	16.74%
0.25	200	0.35	6.32	8.96×10^{-7}	0.72	6.5×10^{-7}	0.002%
0.34	150	0.20	6.21	1.09×10^{-5}	0.61	6.6×10^{-6}	0.02%
0.42	100	0.16	12.11	1.04×10^{-4}	0.68	7.1×10^{-5}	0.18%
0.46	75	0.14	11.41	2.92×10^{-4}	0.64	1.9×10^{-4}	0.47%
0.50	50	0.12	10.71	7.72×10^{-4}	0.62	4.8×10^{-4}	1.19%
0.56	12.5	0.04	9.65	2.95×10^{-3}	0.59	1.7×10^{-3}	4.16%
0.58	1	0.0042	9.33	4.34×10^{-3}	0.54	2.3×10^{-3}	5.59%

Having selected the parameters of interest, one then determines the probability that these conditions will occur and what the risk is of exceeding the values that are planned for the simulation. If it is desired to simulate severe cases of wind shear, then values of μ and u_* should be chosen to have large magnitudes which have correspondingly lower risk. Therefore, a low value of risk is acceptable. Simulating average daily conditions, however, allows a higher risk of exceeding the prescribed stability conditions to be accepted. The percent risk that the user of the wind shear model is willing to accept is subject to his own judgment based on the engineering application for which the simulation is being carried out and on the consequences associated with the test not being of sufficient severity.

One must also bear in mind that the risk of exceeding a prescribed value computed in Section 3.4 and tabulated in Table 3-1 are on a per airport per year basis; consequently, although the probability of $u_* = 0.5$ and $\mu = 200$ occurring simultaneously is $6.2 \times 10^{-1/5}$ (see Table 3-1), for 10,000 airports, this condition will occur at 0.62 of an airport or at least one airport per year. In view of the fact that stability conditions may endure for one or two hours at an airport having heavy traffic, several pilots will be exposed to these conditions every year.

Use of the turbulence simulation routine to be superimposed upon the steady state winds requires no additional specification of atmospheric parameters, however, the time step increment of the random signal, DT, in subroutine STB, must be specified. In general, its value is set equal to the time step used in the calling program carrying out the numerical integration of the equations of motion for the flight dynamics of the aircraft. On the other hand, it can be shown [3-7] that

$$T \leq 4 \times 10^{-4} n_o W_x / z$$

but since this value varies with altitude an average value on the order of 0.01 sec or less is generally recommended for use with the turbulence simulation routine.

In carrying out a realistic simulation, it is recommended that the turbulence be used with the mean wind profile. It is evident from Figures 3-8 through 3-19 that simulation of high stability conditions, that is, large μ, is accompanied with a transition from a rather smooth wind aloft to extremely severe turbulence near the 200 to 100 m range, depending upon the stability. This sort of turbulence phenomenon is expected to be quite realistic judging from comments with commercial airline pilots and from experimental data available in the literature. Super-positioning turbulence on the wind fields, however, does require that a computer be available for carrying out the computations of the wind speeds. This does not impose a hardship because normally, a computer is involved whether the user is performing a manned flight simulation or programming a fast time computer solution.

Without turbulence, however, one can construct a wind speed profile for the neutral or stable boundary layer manually from the tables given in

Appendix 3A. As an example, determine the wind speed profile for $\mu = 50$, $u_* = 0.5$ and $z_0 = 0.05$. To establish the profile one first computes the Rossby number $Ro = u_*/z_0 f = 1 \times 10^7$. This value corresponds to Table 3A-1 in Appendix 3A. Selecting the column labeled $\mu = 50$ gives the wind speed profiles

$\hat{z}$	$\hat{W}_x$	$\hat{W}_y$
0.15	63.4	-32.0
0.10	63.4	-27.2
0.05	59.3	-17.0
0.005	29.5	-4.8
0.0001	24.1	0.0

Dimensional values are obtained from $z = u_* \hat{z}/f$, $W_x = \hat{W}_x u_*$ and $W_y = \hat{W}_y u_*$, hence

z	W_x	W_y
m	m s^{-1}	m s^{-1}
750	31.7	-16.0
500	31.7	-13.6
250	29.6	-9.5
25	14.7	-2.4
5	12.1	0

Thus, wind speed profiles can be established very simply.

3.7 References

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3-8. Guttman, Irwin, and S. S. Wilkes. Introductory Engineering Statistics. New York: John Wiley & Sons, Inc., 1965.

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SECTION 4.0

FRONTAL WIND SHEAR

A model of frontal wind shear has been developed in exactly the same manner as the thunderstorm model. Unfortunately, the number of data sets available for processing are only two, which are shown in their original format in Figures 4-1 and 4-2. These data were provided courtesy of Ms. Judith Stokes and Mr. Jean Lee from the National Severe Storms Laboratory in Norman, Oklahoma. The data represent cold frontal passage in the vicinity of the 500 m tower and the reduction of these data sets is the same as used by Goff [4-1] for thunderstorm gust front cases (see Section 2.2). The data were measured on January 28, 1977, labeled Case 1 in this report, and on December 10, 1976, labeled Case 2.

No other data which would provide the necessary detailed wind speed profiles over at least a two-dimensional plane in space were found during this study. Additional data which is on magnetic tape at the National Severe Storms Laboratory have not yet been processed. No warm front wind shear data from which a model for flight/hazard simulation studies can be constructed appears to be available.

The simulation model developed from the limited data is constructed in the same manner as the thunderstorm models. That is, a grid system is superimposed on the contours of constant wind speed shown in Figures 4-1 and 4-2. In these two cases a 113 x 11 grid is used. The data were again punched on cards and stored on magnetic tape. The only difference between these data and those of the thunderstorm cases is the larger grid having 113 columns rather than 41 which represents a total horizontal distance of approximately 17.2 km in Case 1 and 13.2 km in Case 2. This represents approximately 30 minutes of recorded data.

The following section, Section 4.1, describes the quasi-steady wind speed profile working data developed for the large scale frontal wind shear. The wind speed is referred to as quasi-steady in view of the fact that, as with the thunderstorm data, it has been averaged over 10 sec time intervals and thus contains fluctuations in the wind speed of 0.1 Hz or smaller. It is

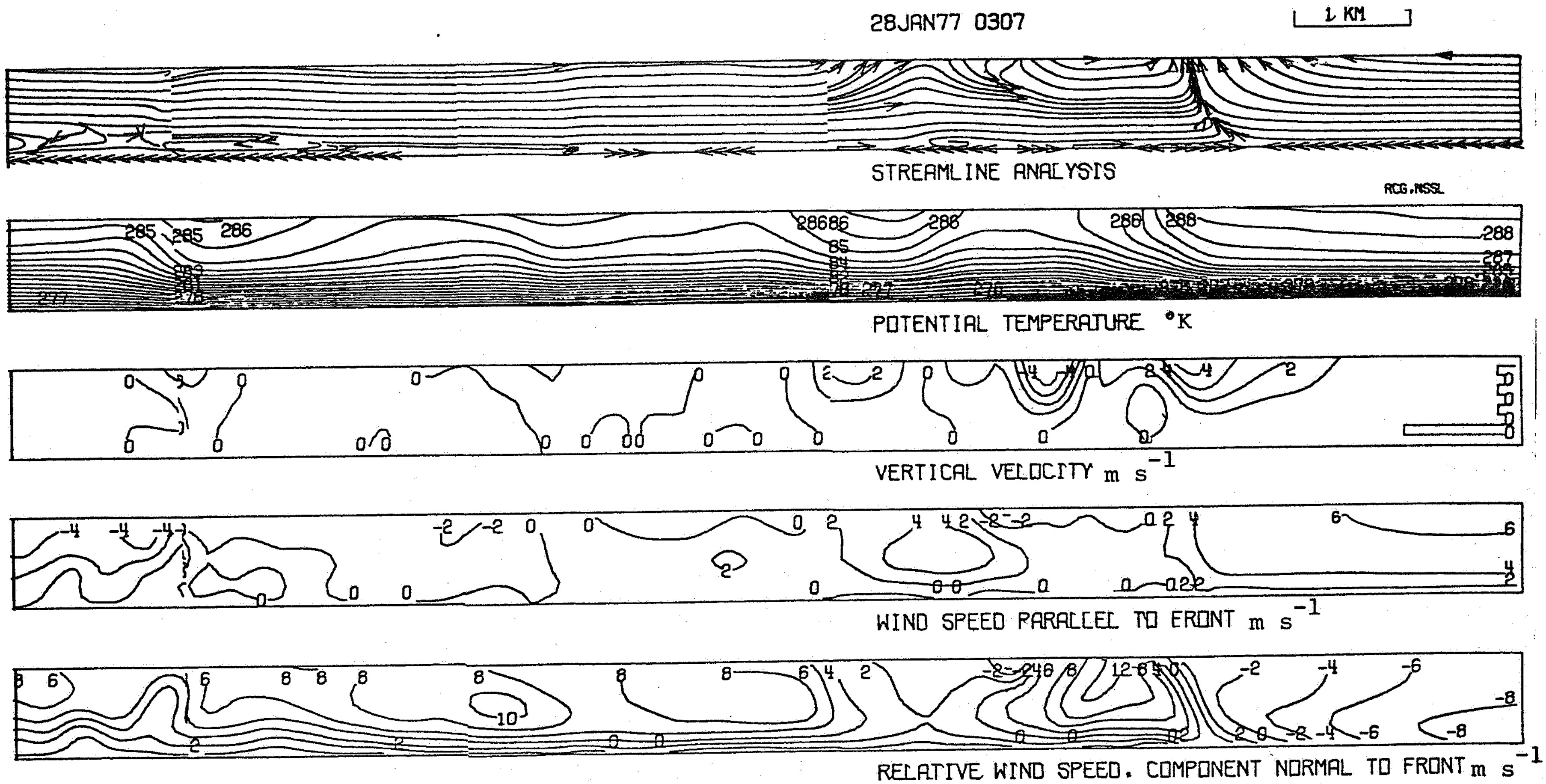

Figure 4-1 Wind Speed for Synoptic Front Cold Air Out-flow

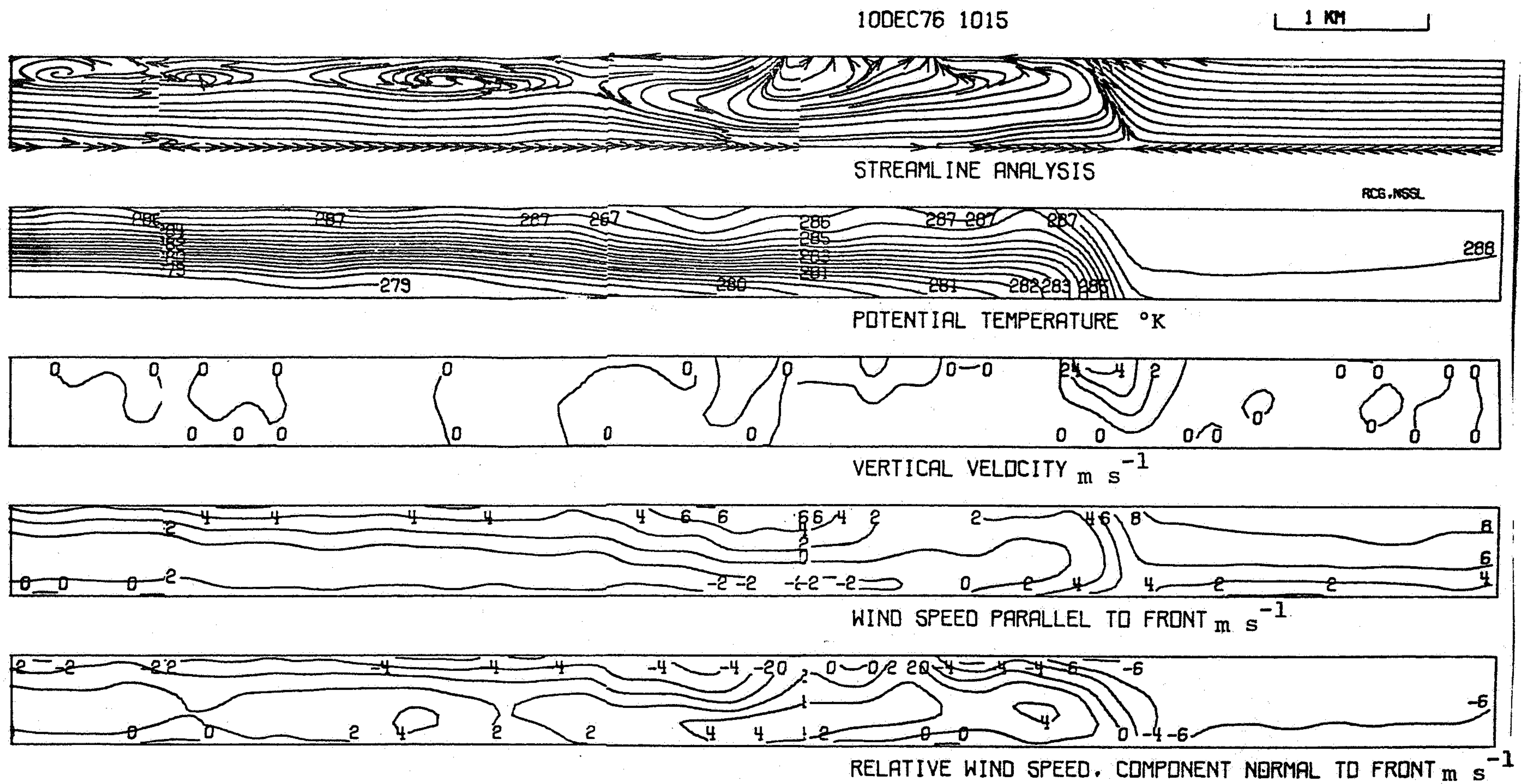

Figure 4-2 Wind Speed for Synoptic Front Cold Air Out-flow

proposed that the same turbulence simulation model for thunderstorms be used for the frontal wind shear. Since absolutely no data was found which would give information pertaining to turbulence intensities and characteristic turbulent length scales in a major frontal flow, the lower values associated with thunderstorms are recommended as input to the model.

4.1 Quasi-Steady Wind Speed Profile Grid System

The wind fields shown in Figures 4-1 and 4-2 were fit to a 113 x 11 point grid system. Wind speeds at each grid point were tabulated and punched onto computer cards. The data were later stored on magnetic tape.

The grid system is numbered from the left-hand bottom corner. The numbers increase from left to right in the positive x-direction and from bottom to top in the positive z-direction of the original data. The wind speeds are given in units of meters per second, $m\ s^{-1}$, with W_x being positive in the direction of frontal motion, W_z being positive upward and W_y being positive into the plane of the paper. The frontal speeds of the two storms are $9.3\ m\ s^{-1}$ and $7.1\ m\ s^{-1}$, respectively.

The wind speeds, W_x, shown in Figures 4-1 and 4-2 are the wind speeds relative to the storm motion which are the values punched on cards and stored on magnetic tape. To convert to wind speed relative to the ground the frontal motion must be added to W_x. The next subsections describe tables and graphical illustrations of the wind speed profiles.

4.1.1 Tables of Wind Speed

Tables of synoptic cold frontal passage wind speeds are given in Appendix 4A. The tables have, due to their length, been split into six parts covering grid stations 1 through 20, 21 through 40, etc. The tabulated values of W_x are values relative to the storm motion. The frontal speed is given at the top of the table for converting W_x to its value relative to ground.

The frontal storm case numbers' designation as 1 and 2 in this report are listed in the upper left-hand corner.

Also, listed at the top of the table is the horizontal length scales for the given wind record. The horizontal extent of each data set varies because of the data reduction procedure. Hence, the length of field, L, in kilometers and the horizontal grid spacing, Δx, are specified on each table. The vertical extent of each field is taken as 500 m with 50 m vertical grid spacing.

4.1.2 Illustrations

Illustrations of the longitudinal, lateral, and vertical wind speeds encountered along four 3° glide slope through each front are provided in Appendix 4B. The glide slopes are displaced in increments of 4.3 km for Case 1 and 3.3 km for Case 2. Each profile is the wind seen by a airplane traveling along the flight path drawn across the streamlines as illustrated in the first figure of the appendix. Note that the streamlines plotted are relative to the speed of the front which for reference purposes is indicated with the vertical dashed line on the horizontal wind speed profile. The wind speed profiles are relative to the fixed earth frame of reference.

4.1.3 Computer Program

The card deck or magnetic tape on which the frontal wind speeds are tabulated can be directly coupled with the program for thunderstorms given in Appendix 2C and requires and provides identical input/output statements. The only modification needed is to increase all dimension statements, do-loop statements and read-in control integers from 41 to 113.

The turbulence option can also be called for if desired. The turbulence intensities σ_{w_x}, σ_{w_y} and σ_{w_z} and length scales L_{w_x}, L_{w_y} and L_{w_z} used in the program all have values as estimated for thunderstorms, however, in lieu of better information on turbulence in major fronts, these values can be used.

4.2 Turbulence Model

No data on turbulence in large frontal flows were found in the literature. It is therefore suggested that the model proposed for the thunderstorm be employed along with the lower values of the input parameters. Recall that data on turbulence in thunderstorms is also very limited in the region near the ground, and the thunderstorm turbulence model is itself an approximation. Again, it is pointed out that only the high frequency components of the turbulence (i.e., frequencies greater than 0.1 Hz) have been lost in the data since the quasi-steady wind field given represent 10 sec averages. There is, however, a very great need to obtain turbulence data in thunderstorms and large fronts in the vicinity of the ground or terminal areas of an airport.

4.3 Statistical Model

Due to the paucity of detailed wind speed data for major fronts, no attempt is made to establish a statistical model of the wind fields.

4.4 Applications of Frontal Wind Shear Model

The frontal wind shear model is applied exactly the same as the thunderstorm models described in Section 2.6. The user, however, has only limited choice of wind fields to use in the simulation since only two fields are available. Keenan [4-2] has used thunderstorm case numbers 2 and 3 as fronts since these two thunderstorms behave in a manner similar to fronts. However, they are extremely short in length and are not long enough for a full length simulation based on an aircraft approaching from 500 m along a 3° glide slope. Such an approach requires a horizontal fetch of 9.5 km. Fortunately the frontal data that are available for the two cases of wind shear studied extend over a sufficiently long distance that a sequence of one or more landings or takeoffs, can be simulated using these data. Up to two landings assuming a 3 mile separation distance can be simulated. Moreover, the wind fields encountered along flight paths separated by small distances show quite dissimilar wind speed profiles as evidenced from the graphical display in Appendix 4B.

Again, it is recommended that turbulence models be used in conjunction with the quasi-steady state wind speeds utilized in developing the frontal wind shear model. It is anticipated that extreme wind speeds will be somewhat averaged out using 10 sec averages, just as described for the thunderstorm models, and therefore to achieve a correct simulation high gusts should be introduced in the form of turbulence. The turbulence intensities used in the model, however, are still open to question, and it is proposed that the lower extremes of turbulent intensities quoted for the thunderstorm cases be utilized for frontal wind shear.

Much more data on fronts is needed before an adequate model of a synoptic front wind field is possible. Such data may be available at the National Severe Storms Laboratory in Norman, Oklahoma, but require further processing. Also, to utilize the 10 sec average wind speeds generated by the NSSL Program effectively, more must be determined about the turbulence levels in major fronts.

One additional set of data that the engineer interested in carrying out warm front simulation should be aware of is a one-dimensional profile compiled by Keenan [4-2]. This model was developed from data obtained in an accident which occurred in Tokyo in 1966. Table 4-1 illustrates the warm front one-dimensional model.

TABLE 4-1

WARM FRONT WIND SPEED PROFILE [4-2]; $W_z = 0$

z (m)	W_x (m s^{-1})	W_y (m s^{-1})
6.1	-6.6	3.9
30.5	-3.6	-2.1
61.0	-4.4	-12.1
91.4	0	-20.6
121.9	5.4	-30.4
152.4	5.9	-33.5
182.9	5.8	-32.9
213.3	5.8	-32.9
243.8	5.7	-32.4
274.3	5.6	-31.9
304.8	5.6	-31.4
457.2	5.9	-31.4

4.5 References

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SECTION 5.0

SUMMARY

Mathematical models of wind fields associated with thunderstorms, neutral and stable boundary layers, and storm fronts have been developed based on reported experimental data. These data have been tabulated and presented in Appendices 2A, 3A and 4A, respectively. Computer programs have been developed which utilize table lookup and interpolation routines to compute wind speeds at spatial positions and under stability conditions as called for by the main calling computer program. These computer programs are presented in Appendices 2C and 3C.

Turbulence simulation techniques have been developed which permit the super-positioning of random fluctuations having the characteristics of turbulence associated with the atmospheric phenomena of interest.

The wind speed models for thunderstorms and major fronts represent the three components of wind velocity in a vertical plane 500 m in extent and of variable lengths in the horizontal direction. In simulating an approach, application of these models assumes that the flight path lies in the plane of the wind speeds with that plane being centered over the runway. These models, therefore, give realistic simulation of wind shear due to a thunderstorm moving parallel to the runway and allow the flight mechanics computation to have departures from the flight path in the vertical direction. Any departure of the aircraft out of the plane in the lateral direction is not accurately modelled. However, evidence is shown that the correlation between the wind components in the x- and z-direction is large and, therefore, it is anticipated that the same is true in the y-direction. Therefore the wind disturbances encountered by an aircraft displaced by the wind a reasonable distance out of the plane of the wind field will be nearly similar to the in-plane winds.

To simulate a flight path which is diagonal to the direction of the motion of the front, one must assume that the wind fields modelled are two-dimensional over a very large lateral scale. This, however, is not likely and to provide wind fields which permit this type of simulation will require considerably more research into the three-dimensional nature of thunderstorms and major fronts.

The turbulence model developed to accompany the mean wind field data are believed to be quite realistic with the exception that the value of the turbulence parameters in the frontal case are vertically unknown. The turbulence model for the neutral and stable boundary layers is based on extensive data sets and theoretical analysis and is believed to be very representative of what happens in the actual atmosphere. The thunderstorm turbulence model is based on advanced turbulence concepts and does include large-scale velocity fluctuations of a non-Gaussian nature, however, coherence matching between large gusts which are in the development stage [5-1] should possibly be added to the simulation technique. Finally, the parametric inputs to the model require better definition which can only be achieved with more experimental effort. Currently, it is proposed to use the values of turbulent intensity measured at elevations of several kilometers because these are the better defined values. Moreover, comparing the thunderstorm data measured by ground based towers to those backed out of on-flight data recorders shows that there is quite a large difference between 10 sec averaged data and much shorter averaging period data. This suggests the available thunderstorm data be reanalyzed using a smaller time increment.

There is considerable need to measure turbulence in the vicinity of the ground, particularly in the downdraft center of thunderstorms and also to measure the gust gradient which could occur in these severe storms phenomena. The same conclusion holds true for large-scale frontal motion where very limited, if any, wind velocity measurements as well as turbulence measurements have been made. The type of measurement which appears most needed would be from an array of towers, preferably 500 m in height, and distributed in a line at least over 1 km in extent. Such an array of towers is obviously very expensive and the data reduction associated with the vast amounts of data generated is, in turn, costly. A tower array is available at NASA Marshall Space Flight Center with the limitations that the towers are only 24 m in height [5-2].

As techniques for remote sensing of wind speed become available, typical examples being laser Doppler, acoustic Doppler or Doppler radar methods, more probing of thunderstorms and of major synoptic fronts will undoubtedly increase.

Aircraft are also being used to study thunderstorms and are providing meaningful data at great altitudes. It is not likely that much probing of thunderstorms or severe frontal weather will be carried out with aircraft below 500 m. However, data at this level is extremely critical in developing simulator wind field models for flight/hazard definition.

A possible technique for obtaining the needed data would be to couple aircraft measurements with those of the tower array currently in existence at the Atmospheric Sciences Division, NASA/Marshall Space Flight Center, Huntsville, Alabama. A coordinated program utilizing aircraft passes over the tower array with the towers in operation would map out a well defined two-dimensional wind field and could also provide three-dimensional wind fields when the angle of the approaching storm is oblique to the tower array.

Mathematical models currently being developed have promise for use in wind shear simulation applications, however, they are, in turn, dependent upon input parameters which must be experimentally measured before meaningful results can be calculated.

A statistical model for the stable and neutral boundary layer has been developed which allows the probability of a given wind speed and stability condition occurring simultaneously to be estimated. The model also predicts the frequency of the combined conditions occurring within a specified period of time. This model assumes a Rayleigh distribution of wind speeds for any given site in the mainland U.S.A. This is a justifiable assumption based on a study of 138 sites by Justus, et al. [5-3]. The probability distribution of Richardson numbers is not quite as well validated, being based on only two sets of data. It is believed, however, that this is a good estimate of the distribution of stability conditions with wind speeds.

The statistical model for the thunderstorm is rather weak and for the synoptic fronts nonexistent. The best estimate of the probability of a given magnitude of wind shear in a thunderstorm that is currently available is based on the ensemble average of 20 thunderstorm cases along a prescribed flight path and the standard deviation from the averaged value. These computed standard deviations are added at each point along the flight path as if they were independent points. This is a questionable assumption and further work is needed to develop the statistical model of a thunderstorm.

Before a statistical model of fronts can be developed much more data is needed. Due to the lack of measurements of detailed wind speed profiles through large fronts and also, to an extent, through thunderstorms, reliable simulation flight/hazard wind speed models cannot be developed.

The conclusion of this report is that mathematical models of wind shear in thunderstorms, stable and neutral boundary layers and fronts for flight/hazard simulation studies have been developed which, based on state of the art knowledge, allow realistic simulation of flight through hazardous atmospheric wind shear. These models, however, represent a very good beginning but they should be continuously updated as information becomes available and standardized to establish consistent criteria for pilot training, avionics development and aircraft design and certification.

5.1 References

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APPENDICES

The following appendices are numbered according to the section of the main body of the report to which they pertain. For example, Appendix 2 followed by an alphabetical symbol contains information relating to Section 2, Thunderstorm Wind Shear. Appendices 3 and 4 are referenced in the same format.

APPENDIX 1A

LIST OF ABBREVIATIONS AND SYMBOLS

u_*	Friction velocity
μ	Stability parameter, $\kappa u_*/fL'$
f	Coriolis parameter
L'	Monin-Obukhov stability length scale
L	Horizontal extent of thunderstorm data set
κ	von Karman's constant taken as 0.4
L_{w_x}	Length scale of longitudinal velocity fluctuations
L_{w_y}	Length scale of lateral velocity fluctuations
L_{w_z}	Length scale of vertical velocity fluctuations
$\overline{W}_x$	Mean speed of storm front
W_x	Longitudinal wind speed
W_y	Lateral wind speed
W_z	Vertical wind speed
w_x	Fluctuating longitudinal wind speed
w_y	Fluctuating lateral wind speed
w_z	Fluctuating vertical wind speed
z_o	Surface roughness
z	Dimensional height
$\hat{z}$	Dimensionless height $\hat{z} = zf/u_*$
Ro	Rossby number u_*/fz_o
$\phi(n)$	Power density spectrum function
n	Cyclic frequency
σ_α	Turbulence intensity of α wind speed fluctuation

$\rho_{\alpha\beta}$	Statistical correlation between α and β wind speed components
< >	Ensemble average
^	Denotes dimensionless parameter

APPENDIX 2A

TABULATED THUNDERSTORM DATA

Appendix 2A contains the tabulated data interpolated from the thunderstorm wind speed data presented and documented in Goff [2-1]. These data are the fundamental data sets upon which the wind shear model for thunderstorms is based. The user can compute wind speed profiles either by hand directly from the tables or by coupling the data with the lookup computer program provided in Appendix 2C.

The rows and columns of the table are numbered from the left-hand bottom corner. The numbers increase from left to right in the positive x-direction of the original data and from bottom to top in the positive z-direction of the original data. The wind speeds are given in units of meters per sec, m s^{-1}, with W_x being positive in the direction of frontal motion, W_z being positive upward and W_y being positive into the plane of the paper. The upper portion of the table covers columns 1 through 21 and the lower table covers columns 21 through 41. (Note column 21 is repeated for symmetry and clarity of presentation.)

The thunderstorm case numbers' designation for this report are listed at the top of the table. The letters in parentheses and the following series number correspond to the thunderstorm designation given by Goff [2-1].

Also listed at the top of the table are the frontal speed, $\overline{W}_x$, and the horizontal length scales for the given wind record. The horizontal extent of each data set varies because of the data reduction procedure. Hence, the length of field, L, in meters and the horizontal grid spacing, Δx, (m) are specified on each table. The vertical extent of each field is taken as 500 m with 50 m vertical grid spacing. Figure 2A-1 illustrates the identification format used for all tables.

ILLUSTRATION OF TABLE DESIGNATING SYMBOLS

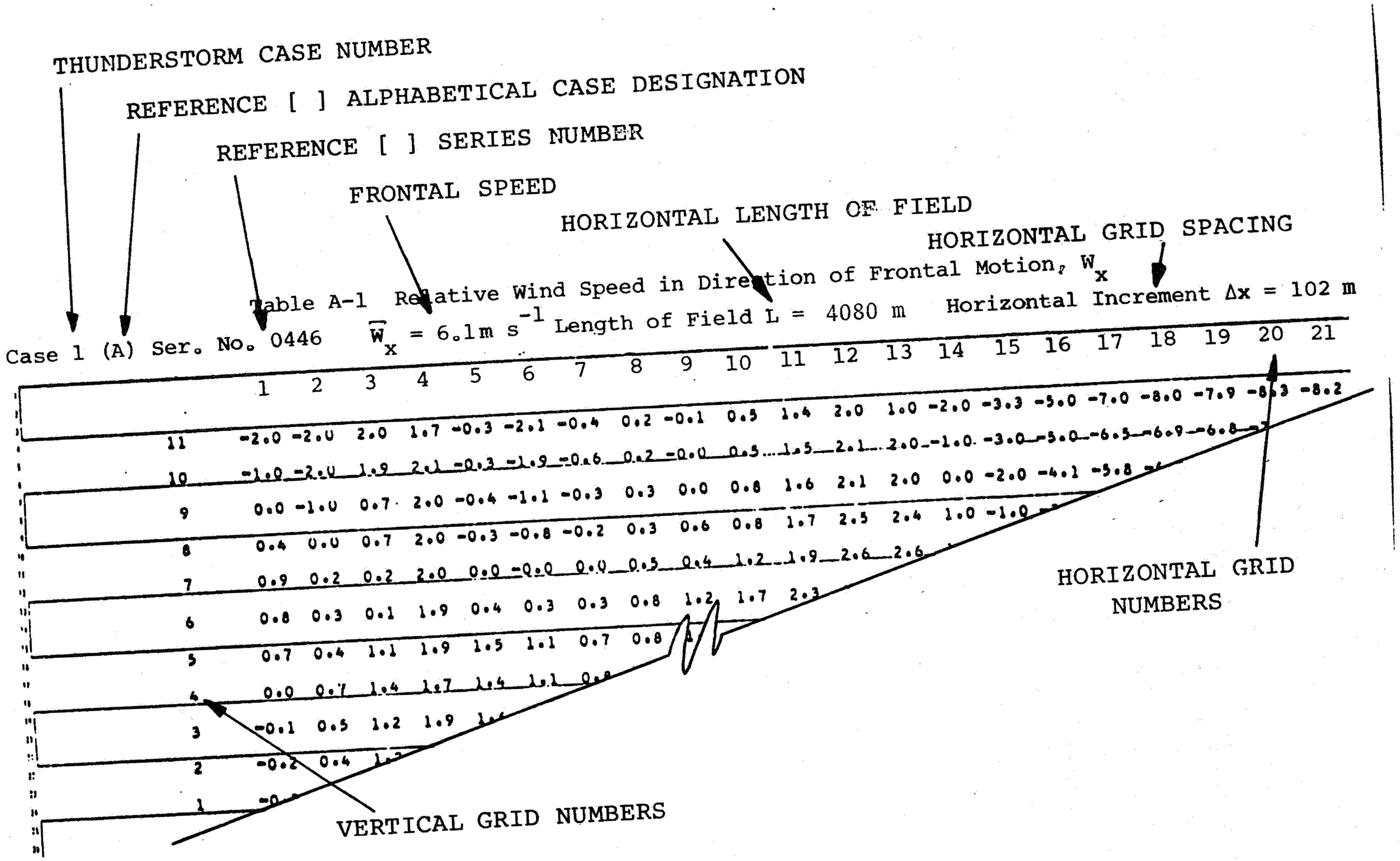

Figure 2A-1 Identification Format for All Tables in Appendix 2A

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Table 2A-1(a) Wind Speed in Direction of Frontal Motion, W_x

Case 1(A) Series No. 0446,

$\overline{W}_x = 6.1 \text{ m s}^{-1}$, Length of Field L = 4000 m, Horizontal Increment Δx = 100 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	4.1	4.1	4.1	6.1	8.1	8.5	7.8	7.1	5.8	4.9	4.0	4.8	5.7	6.0	6.3	6.2	6.0	6.1	6.6	7.0	7.5
10	5.1	4.1	4.1	5.9	8.0	8.4	8.2	7.0	5.8	5.0	4.2	4.9	5.5	6.2	6.3	6.2	6.0	6.2	6.6	7.1	7.6
9	6.1	5.6	5.1	4.9	6.8	8.4	8.1	6.9	5.7	5.3	5.0	5.4	5.8	6.2	6.4	6.3	6.2	6.5	6.9	7.3	7.7
8	6.5	6.3	6.1	5.1	6.8	8.4	8.1	7.1	5.8	5.5	5.3	5.6	5.9	6.2	6.4	6.5	6.7	6.8	6.9	7.4	7.8
7	7.0	5.6	6.3	5.9	6.3	8.6	8.1	7.1	6.1	6.1	6.1	6.1	6.1	6.3	6.6	6.5	6.5	6.9	7.3	7.7	8.1
6	6.9	6.6	6.4	6.1	6.2	8.2	8.1	7.3	6.5	6.5	6.4	6.4	6.4	6.6	6.9	7.1	7.3	7.6	7.8	8.1	8.4
5	6.8	6.7	6.5	6.4	7.3	8.1	8.0	7.8	7.6	7.4	7.2	7.0	6.8	6.6	6.9	7.1	7.4	7.7	7.9	8.2	8.6
4	6.1	6.5	6.8	7.2	7.5	7.9	7.8	7.6	7.5	7.3	7.2	7.1	6.9	6.8	7.0	7.3	7.5	7.8	8.0	8.5	9.1
3	6.0	6.2	6.6	6.9	7.3	7.6	8.0	7.9	7.7	7.6	7.4	7.3	7.2	7.0	6.9	7.2	7.5	7.8	8.1	8.7	9.3
2	5.9	6.1	6.5	6.9	7.3	7.7	8.1	8.3	8.1	7.9	7.7	7.5	7.3	7.1	6.9	7.3	7.6	7.9	8.2	8.8	9.5
1	5.8	5.9	6.1	6.6	7.1	7.6	8.1	8.4	8.3	8.1	7.9	7.7	7.4	7.2	7.0	7.3	7.7	8.0	8.7	9.4	10.1

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	7.5	8.0	8.1	8.1	7.1	6.1	4.1	3.4	2.8	2.1	1.1	0.1	-0.9	-1.9	-2.0	-2.0	-1.8	-1.9	-2.2	-2.5	-2.1
10	7.6	8.1	8.2	8.1	8.1	6.6	5.1	4.1	3.1	2.1	1.1	0.1	-0.4	-0.9	-0.8	-0.8	-0.7	-1.1	-1.6	-2.0	-1.8
9	7.7	8.1	8.2	8.2	8.1	8.0	6.1	5.1	4.1	3.0	2.0	1.2	0.3	0.2	0.1	0.2	0.3	-0.4	-1.1	-1.0	-0.8
8	7.8	8.3	8.6	8.9	8.5	8.1	7.1	6.1	5.1	4.1	3.1	2.1	1.6	1.1	1.1	1.2	1.2	0.3	-0.4	-0.3	-0.3
7	8.1	8.4	8.7	9.1	8.7	8.3	7.5	6.8	6.1	5.1	4.0	3.0	2.1	2.0	2.0	2.0	2.1	1.2	0.2	0.2	0.2
6	8.4	8.7	9.0	9.3	8.9	8.4	8.0	6.7	5.4	4.1	4.1	4.1	3.5	2.9	2.8	2.7	2.6	2.1	1.8	1.4	1.1
5	8.6	9.0	9.4	9.8	9.2	8.7	8.1	7.4	6.8	6.1	5.4	4.8	4.1	3.8	3.6	3.3	3.1	2.7	2.3	1.9	1.4
4	9.1	9.6	10.1	10.2	9.3	8.7	8.2	7.8	7.2	6.7	6.1	5.6	5.1	4.6	4.1	4.2	4.1	3.6	3.1	2.5	1.9
3	9.3	9.9	10.2	10.2	9.8	9.2	8.5	7.9	7.5	7.2	6.8	6.5	6.1	5.8	5.4	5.1	4.8	4.4	4.1	3.1	2.1
2	9.5	10.1	10.2	10.3	10.1	9.2	8.3	8.0	7.8	7.5	7.2	6.9	6.7	6.4	6.1	5.6	5.1	4.6	4.1	3.6	3.1
1	10.1	10.2	10.3	10.4	10.2	9.4	8.6	7.9	7.7	7.4	7.2	7.0	6.8	6.5	6.3	6.1	5.7	5.3	4.9	4.5	4.1

Table 2A-1(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 1(A) Series No. 0446,

$\overline{W}_x = 6.1 \text{ m s}^{-1}$, Length of Field L = 4000 m, Horizontal Increment Δx = 100 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.5	-1.5	-2.4	-3.4	-3.0	-2.8	-2.5	-2.8	-3.0	-3.2	-3.4	-3.3	-3.1	-2.9	-2.7	-2.4	-2.2	-1.9	-1.5	-1.2	-0.9
10	-0.5	-1.4	-2.4	-3.3	-3.0	-2.8	-2.5	-2.7	-2.8	-3.0	-3.3	-3.2	-3.0	-2.8	-2.5	-2.3	-2.0	-1.8	-1.5	-1.2	-1.0
9	-0.5	-1.4	-2.2	-3.1	-2.9	-2.7	-2.5	-2.7	-2.9	-3.1	-2.9	-2.8	-2.6	-2.5	-2.3	-2.2	-2.0	-1.8	-1.6	-1.5	-1.3
8	-0.5	-1.3	-2.0	-2.8	-2.7	-2.6	-2.5	-2.7	-2.8	-3.0	-2.9	-2.7	-2.6	-2.5	-2.3	-2.2	-2.0	-1.9	-1.7	-1.5	-1.3
7	0.0	-1.1	-2.3	-2.2	-2.0	-2.1	-2.3	-2.4	-2.5	-2.4	-2.3	-2.3	-2.2	-2.1	-2.0	-1.9	-1.8	-1.6	-1.5	-1.4	-1.2
6	0.0	-1.0	-2.0	-1.9	-1.8	-1.7	-1.9	-2.0	-2.2	-2.1	-2.0	-1.9	-1.8	-1.6	-1.5	-1.4	-1.2	-1.1	-1.0	-1.0	-1.1
5	0.0	-1.0	-1.2	-1.4	-1.6	-1.8	-2.0	-2.0	-2.0	-2.0	-2.0	-1.8	-1.7	-1.5	-1.3	-1.2	-1.0	-1.0	-1.0	-1.0	-1.0
4	0.0	-1.0	-1.5	-1.5	-1.5	-1.4	-1.4	-1.4	-1.4	-1.3	-1.3	-1.3	-1.2	-1.2	-1.2	-1.1	-1.0	-0.8	-0.7	-0.6	-0.5
3	0.5	0.0	-0.9	-0.9	-0.8	-0.9	-1.1	-1.2	-1.1	-1.0	-0.9	-1.0	-1.1	-1.0	-0.9	-0.8	-0.7	-0.6	-0.5	-0.6	-0.6
2	0.5	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.4	-0.4	-0.5	-0.5	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.9	-0.5	-0.1	0.6	1.2	2.1	3.0	4.0	4.2	4.0	3.0	2.8	2.5	2.3	2.0	1.7	1.3	1.0	0.8	0.5	0.3
10	-1.0	-0.7	-0.3	0.0	1.0	2.0	2.5	3.0	3.8	3.0	2.7	2.5	2.3	2.2	2.0	1.7	1.3	1.0	0.8	0.5	0.3
9	-1.3	-1.1	-0.9	0.0	0.7	1.3	2.0	2.5	2.9	2.5	2.0	2.1	2.2	2.0	1.7	1.5	1.2	1.0	0.8	0.5	0.3
8	-1.3	-1.2	-1.0	-0.2	0.6	0.9	1.3	1.6	2.0	1.9	1.8	2.0	2.1	1.9	1.6	1.4	1.1	0.9	0.7	0.4	0.2
7	-1.2	-1.1	-1.0	-0.2	0.5	1.1	1.7	1.5	1.4	1.2	1.0	1.1	1.2	1.2	1.3	1.4	1.1	0.8	0.6	0.3	0.0
6	-1.1	-0.7	-0.3	0.1	0.5	0.7	1.0	0.9	0.9	0.9	0.8	0.9	1.0	1.0	1.0	1.0	1.1	0.8	0.6	0.3	0.0
5	-1.0	-1.0	-1.0	-0.4	0.1	1.0	1.2	1.1	1.0	0.9	0.8	0.9	1.0	0.9	0.8	1.0	1.2	0.9	0.6	0.3	0.0
4	-0.5	-0.4	-0.2	-0.1	0.0	1.0	1.0	0.9	0.7	0.6	0.5	0.6	0.8	0.9	1.1	1.2	0.9	0.6	0.3	0.0	0.0
3	-0.6	-0.4	-0.3	-0.2	0.0	0.8	0.6	0.4	0.2	0.0	0.2	0.5	0.0	0.2	0.5	1.0	0.7	0.5	0.2	0.0	0.0
2	-0.2	-0.1	-0.1	0.0	0.0	0.2	0.5	0;3	0.2	0.0	0.2	0.5	0.2	0.0	0.2	0.5	0.3	0.2	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2A-1(c) Vertical Wind Speed, W_Z

Case 1(A) Series No. 0446,

$\bar{W}_x = 6.1\ \mathrm{m\ s^{-1}}$, Length of Field L = 4000 m, Horizontal Increment Δx = 100 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.0	1.0	2.0	2.7	3.5	4.2	3.0	1.9	0.8	1.6	2.5	3.3	4.1	4.0	3.8	4.0	4.2	4.1	4.0	3.6	3.2
10	-1.0	-0.5	0.0	1.0	2.0	3.0	1.5	0.0	-0.2	0.5	1.3	2.0	2.2	2.5	2.7	3.0	3.2	3.0	2.8	2.6	2.4
9	-2.0	-1.5	-1.0	-0.5	0.0	0.9	0.0	-1.0	-2.0	-1.0	0.0	0.5	1.0	1.2	1.5	1.8	2.0	1.7	1.4	1.1	0.9
8	-2.1	-2.2	-2.4	-2.5	-1.8	-1.0	-2.0	-2.9	-2.5	-2.0	-1.6	-1.2	-0.8	-0.4	0.0	0.1	0.1	0.2	0.3	0.3	0.4
7	-2.2	-2.8	-3.4	-4.0	-3.0	-2.1	-3.0	-4.0	-3.3	-2.7	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0
6	-2.5	-3.3	-4.0	-4.0	-4.0	-3.6	-3.2	-4.1	-3.7	-3.4	-3.0	-2.7	-2.3	-2.0	-1.8	-1.6	-1.5	-1.3	-1.1	-0.9	-0.8
5	-2.6	-3.3	-4.0	-4.1	-4.1	-4.0	-3.8	-4.0	-3.8	-3.5	-3.3	-3.0	-2.8	-2.6	-2.3	-2.1	-2.1	-2.0	-2.0	-1.7	-1.4
4	-2.7	-3.3	-4.0	-4.1	-4.1	-4.0	-3.9	-3.8	-3.7	-3.5	-3.4	-3.3	-3.1	-3.0	-2.8	-2.7	-2.5	-2.4	-2.3	-2.1	-2.0
3	-2.8	-3.4	-4.0	-4.0	-4.0	-4.0	-3.9	-3.7	-3.6	-3.5	-3.3	-3.2	-3.1	-3.0	-2.8	-2.7	-2.6	-2.4	-2.3	-2.2	-2.0
2	-2.8	-3.4	-4.0	-4.0	-4.0	-4.0	-3.9	-3.7	-3.6	-3.5	-3.4	-3.3	-3.1	-3.0	-2.9	-2.8	-2.6	-2.5	-2.4	-2.3	-2.1
1	-2.3	-2.7	-3.2	-3.6	-4.0	-4.0	-4.0	-3.9	-3.7	-3.6	-3.5	-3.3	-3.2	-3.1	-2.9	-2.8	-2.7	-2.5	-2.4	-2.3	-2.1

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	3.2	2.8	2.4	2.0	1.8	1.6	3.4	5.1	6.9	8.7	10.4	12.2	12.0	11.8	11.6	11.4	11.3	11.1	10.9	10.7	10.5
10	2.4	2.2	2.0	1.8	1.7	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	11.8	11.6	11.4	11.3	11.1	10.9	10.7	10.5
9	0.9	0.6	0.3	0.0	0.5	1.0	1.5	2.0	4.0	6.0	8.0	10.0	10.1	10.3	10.4	10.4	10.3	10.3	10.3	10.2	10.2
8	0.4	0.2	0.1	-0.1	0.4	0.9	1.3	1.8	3.4	5.1	6.7	8.4	10.0	10.2	10.4	10.2	10.1	9.9	10.0	10.1	10.2
7	0.0	-0.1	-0.2	-0.3	-0.1	0.1	0.7	1.4	2.0	3.8	5.6	7.3	9.1	9.6	10.0	9.8	9.7	9.5	9.7	9.8	10.0
6	-0.8	-0.6	-0.4	-0.2	-0.1	0.1	0.7	1.4	2.0	2.6	4.4	6.2	8.0	8.4	8.9	8.9	9.0	9.0	9.0	9.1	9.1
5	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	0.0	0.0	1.0	2.0	3.3	4.7	6.0	7.0	8.0	8.0	8.0	8.0	8.0	8.1	8.2
4	-2.0	-1.7	-1.5	-1.2	-0.9	-0.6	-0.4	-0.1	0.6	1.3	2.0	3.0	4.0	5.0	6.0	6.3	6.6	6.9	7.3	7.6	7.9
3	-2.0	-1.9	-1.6	-1.3	-1.0	-0.8	-0.5	-0.2	0.1	0.6	1.0	1.5	2.0	3.0	4.1	5.0	5.9	6.0	6.2	6.3	6.5
2	-2.1	-2.0	-1.7	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	0.4	0.3	0.1	0.0	1.5	3.1	4.1	4.5	4.9	5.3	5.7	6.1
1	-2.1	-2.0	-1.8	-1.5	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	-0.1	-0.2	0.5	1.3	2.0	3.0	4.0	4.5	5.0	5.5	6.0

Table 2A-2(a) Wind Speed in Direction of Frontal Motion, W_x

Case 2(B) Series No. 1314,

$\overline{W}_x = 5.0 \text{ m s}^{-1}$, Length of Field L = 3278.8 m, Horizontal Increment Δx = 81.97 meters.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	4.5	7.0	7.3	7.7	8.0	8.2	8.4	8.6	9.1	9.5	10.0	9.4	8.8	8.2	7.1	6.1	5.0	3.0	2.7	2.3	2.0
10	4.6	6.5	7.3	8.1	8.3	8.6	8.8	8.9	9.0	9.3	9.5	9.8	9.0	8.2	7.7	7.1	5.8	4.4	3.0	2.6	2.2
9	4.6	6.3	7.3	8.3	8.7	9.0	9.0	9.0	9.7	10.3	11.0	9.9	8.8	8.3	7.8	7.4	7.0	5.9	5.0	3.6	3.0
8	4.6	6.1	7.5	8.8	9.2	9.5	9.4	9.2	10.1	11.0	10.5	10.0	9.3	8.6	7.9	7.7	7.5	7.3	6.5	5.8	5.0
7	4.7	6.5	7.8	9.0	9.5	10.0	9.8	9.6	10.1	10.5	11.0	10.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	7.8	6.5
6	4.7	6.8	8.1	9.3	10.0	10.7	10.6	10.4	10.3	10.3	10.2	10.2	10.1	10.0	10.1	10.1	10.2	10.0	9.8	8.9	8.0
5	4.8	7.0	9.0	10.0	10.5	11.0	11.0	11.0	11.0	11.3	11.6	11.5	11.4	11.2	11.1	11.0	11.1	11.2	11.0	10.0	9.0
4	5.0	7.0	9.0	11.0	11.3	11.5	11.3	11.2	11.0	11.5	12.0	11.7	11.3	11.0	11.1	11.3	11.4	10.9	10.5	10.0	9.0
3	5.5	8.0	10.5	11.5	11.7	11.8	11.0	10.5	10.0	10.3	10.7	11.0	11.2	11.3	11.5	11.4	11.3	11.1	11.0	10.0	9.0
2	6.4	11.0	12.0	12.3	12.5	11.9	11.3	10.4	9.5	10.3	11.0	11.2	11.4	11.3	11.2	11.2	11.1	11.0	9.5	8.3	7.0
1	7.0	13.0	13.2	13.1	13.0	12.2	11.3	10.4	9.4	9.0	9.8	10.7	11.5	11.3	11.0	9.9	8.7	7.6	6.5	7.0	7.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	2.0	1.5	1.0	0.7	0.4	0.1	-0.2	-0.7	-1.1	-1.5	-1.9	-2.4	-2.8	-2.8	-2.9	-2.9	-3.0	-3.2	-3.4	-3.5	-3.7
10	2.2	1.8	1.4	1.0	0.7	0.3	0.0	-0.5	-1.0	-1.4	-1.8	-2.2	-2.4	-2.6	-2.9	-3.1	-3.3	-3.4	-3.4	-3.4	-3.5
9	3.0	2.5	1.9	1.4	0.9	0.5	0.0	-0.4	-0.9	-1.3	-1.8	-2.4	-3.1	-3.1	-3.2	-3.2	-3.3	-3.3	-3.3	-3.4	-3.4
8	5.0	3.0	2.5	1.9	1.0	0.7	0.3	-0.1	-0.6	-1.0	-1.7	-2.3	-3.0	-3.1	-3.1	-3.2	-3.3	-3.4	-3.4	-3.4	-3.5
7	6.5	4.8	3.0	2.4	1.8	1.4	1.0	0.6	0.2	-0.2	-1.0	-1.5	-2.0	-2.5	-3.0	-3.3	-3.5	-3.7	-4.0	-3.7	-3.4
6	8.0	6.0	5.0	3.6	2.2	1.9	1.7	1.4	0.7	0.0	-0.5	-1.0	-1.5	-2.0	-2.3	-2.7	-3.0	-3.1	-3.1	-3.2	-3.3
5	9.0	7.5	6.0	4.5	3.0	2.5	2.1	1.5	1.0	0.6	0.2	-0.9	-2.0	-2.2	-2.3	-2.4	-2.6	-2.7	-2.8	-2.9	-3.0
4	9.0	8.0	7.0	6.0	4.5	3.0	2.6	2.3	1.9	1.3	0.6	0.0	-0.4	-0.9	-1.3	-1.8	-2.2	-2.7	-3.2	-3.1	-2.9
3	9.0	8.2	7.3	6.3	5.4	4.6	3.7	3.3	2.8	2.0	1.3	0.6	-0.2	-0.5	-0.8	-1.3	-1.8	-2.5	-3.2	-2.7	-2.2
2	7.0	7.1	7.2	6.5	5.8	5.4	5.0	4.8	4.6	3.3	2.0	1.2	0.5	0.0	-0.5	-1.0	-1.7	-2.5	-3.2	-2.8	-2.4
1	7.5	7.4	7.3	6.7	6.0	6.1	6.2	6.3	6.4	4.7	3.0	1.6	0.2	-0.1	-0.4	-1.0	-1.6	-2.3	-3.0	-2.8	-2.5

Table 2A-2(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 2(B) Series No. 1314,

$\overline{W}_x = 5.0\ \mathrm{m\ s^{-1}}$, Length of Field L = 3278.8 m, Horizontal Increment Δx = 81.97 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.8	-1.6	-1.5	-1.3	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	0.6	1.3	1.0	0.8	1.0	1.3	1.5	2.1	2.8	3.4	4.0
10	-1.8	-1.7	-1.5	-1.4	-1.2	-1.0	-0.9	-0.9	-0.8	0.1	0.9	0.7	0.6	0.4	0.7	1.0	1.3	1.9	2.4	3.0	3.3
9	-1.6	-1.4	-1.2	-1.1	-1.1	-1.0	0.0	-0.5	-1.0	-0.2	0.6	0.3	0.0	0.1	0.2	1.0	1.3	1.7	2.0	2.3	2.5
8	-1.5	-1.4	-1.2	-1.1	-1.1	-0.5	0.1	0.1	0.0	-0.1	0.1	0.2	0.1	0.0	-0.1	0.5	1.0	1.5	1.8	2.0	2.1
7	-1.5	-1.2	-1.0	-1.0	-1.0	-0.3	0.3	0.3	0.2	0.2	0.2	0.0	0.0	-0.1	-0.1	0.4	1.1	1.3	1.5	1.6	1.8
6	-1.5	-1.3	-1.0	-0.7	-0.4	-0.1	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	0.0	0.5	0.9	1.4	1.5	1.6
5	-1.3	-1.2	-0.9	-0.6	-0.3	0.0	0.5	1.0	0.5	-0.1	-0.1	-0.2	-0.3	-0.2	-0.1	0.0	1.0	1.1	1.2	1.3	1.4
4	-1.1	-1.1	-0.8	-0.5	-0.2	0.0	0.5	1.0	0.4	-0.1	-0.2	-0.4	-0.5	-0.3	-0.2	-0.1	0.5	1.0	1.0	1.0	1.0
3	-1.0	-1.0	-0.7	-0.4	-0.2	0.0	0.1	0.2	0.0	-0.1	-0.3	-0.4	-0.6	-0.4	-0.2	-0.1	0.4	0.9	0.9	0.9	0.9
2	-0.9	-0.8	-0.7	-0.4	-0.2	0.3	0.8	0.4	0.1	-0.3	-0.7	-0.7	-0.8	-0.5	-0.3	0.0	0.2	0.4	0.4	0.4	0.4
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	4.0	4.1	4.2	4.2	4.3	4.2	4.2	4.1	4.1	4.0	3.8	3.7	3.5	3.3	3.2	3.0	2.7	2.3	2.0	1.3	0.6
10	3.3	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.8	3.7	3.5	3.3	3.1	3.0	2.8	2.6	2.3	2.0	1.3	0.6
9	2.5	2.8	3.0	3.3	3.5	3.4	3.3	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.4	2.0	1.5	1.1	0.7
8	2.1	2.2	2.3	2.4	2.6	2.7	2.8	2.9	3.0	2.9	2.8	2.7	2.6	2.4	2.3	2.2	2.1	2.0	1.6	1.2	0.8
7	1.8	2.0	2.2	2.3	2.5	2.6	2.8	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.8	1.6	1.2	0.9
6	1.6	1.7	1.8	1.9	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.1	0.9
5	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.6	1.5	1.3	1.0	0.8
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	0.7
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.6
2	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2A-2(c) Vertical Wind Speed, W_Z

Case 2(B) Series No. 1314,

$\overline{W}_x = 5.0 \text{ m s}^{-1}$, Length of Field L = 3278.8 m, Horizontal Increment Δx = 81.97 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-2.1	-1.0	0.1	0.3	0.4	0.6	0.8	0.5	0.3	0.0	0.0	0.0	0.0	0.3	0.7	0.5	0.2	0.0	-0.2	-2.6	-4.9
10	-2.1	-1.0	0.1	0.3	0.5	0.6	0.8	1.0	1.2	0.6	0.0	0.3	0.6	0.8	1.1	0.7	0.4	0.0	-1.6	-3.2	-4.8
9	-2.1	-1.0	0.1	0.4	0.7	1.0	1.4	1.7	2.0	1.5	0.9	1.1	1.4	1.6	1.9	1.3	0.7	0.1	-0.5	-1.7	-2.8
8	-2.1	-1.0	0.1	0.5	0.9	1.2	1.6	2.0	2.0	2.0	1.5	0.9	1.5	2.0	1.7	1.3	1.0	0.7	0.3	0.0	-1.4
7	-2.1	-1.0	0.0	0.1	0.1	0.2	0.2	2.0	2.0	2.0	2.0	1.2	1.6	2.0	1.8	1.7	1.5	1.7	1.8	2.0	1.0
6	-2.1	-1.0	0.0	0.0	0.0	0.0	0.5	1.0	1.6	2.1	2.0	1.8	1.9	2.0	1.9	1.7	1.6	1.8	2.0	2.0	2.0
5	-2.0	-1.3	-0.7	0.0	0.0	0.0	0.0	0.7	1.5	2.2	2.1	2.1	2.0	1.9	1.7	1.6	1.7	1.9	2.0	2.2	2.4
4	-1.0	-0.9	-0.7	-0.6	-0.4	-0.2	-0.1	1.0	2.1	2.1	2.2	2.2	2.0	1.9	1.7	1.5	1.7	1.9	2.1	2.7	3.2
3	0.0	-0.5	-1.0	-1.5	-2.0	-1.0	-0.1	0.9	2.0	2.1	2.2	2.0	1.9	1.7	1.6	1.4	1.9	2.4	3.0	3.5	4.0
2	0.0	0.0	0.0	-1.0	-2.0	-1.0	0.0	1.0	2.0	2.1	2.2	2.1	2.1	2.0	1.7	1.4	1.7	2.0	2.5	3.1	3.7
1	0.1	-0.5	-1.0	-1.6	-2.2	-1.1	0.0	0.7	1.3	2.0	2.1	2.2	2.1	2.0	1.8	1.5	1.8	2.0	2.7	3.5	4.2

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-4.9	-7.3	-9.6	-12.0	-12.0	-12.1	-12.1	-12.5	-12.9	-13.2	-13.6	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0
10	-4.8	-6.4	-8.0	-9.3	-10.5	-11.0	-11.5	-12.0	-12.5	-13.0	-13.5	-14.0	-14.0	-14.1	-14.1	-14.1	-14.1	-14.1	-14.0	-14.0	-14.0
9	-2.8	-4.0	-5.5	-7.0	-8.5	-10.0	-10.7	-11.5	-12.2	-12.7	-13.1	-13.6	-14.1	-14.1	-14.1	-14.1	-14.1	-14.0	-14.0	-14.0	-14.0
8	-1.4	-2.8	-4.2	-5.6	-7.0	-8.3	-9.5	-10.8	-12.0	-12.5	-13.0	-13.5	-14.0	-14.0	-14.0	-14.0	-14.1	-14.1	-14.1	-14.1	-14.1
7	1.0	0.0	-1.3	-2.7	-4.0	-5.5	-7.1	-8.6	-10.1	-11.1	-12.1	-12.7	-13.4	-14.0	-14.0	-14.1	-14.1	-14.1	-14.1	-14.2	-14.2
6	2.0	2.0	1.0	0.0	-2.0	-3.9	-5.4	-6.9	-8.5	-10.0	-10.9	-11.9	-12.6	-13.3	-14.0	-14.0	-14.1	-14.1	-14.1	-14.2	-14.2
5	2.4	2.2	2.0	0.6	-0.9	-2.3	-3.7	-5.1	-6.6	-8.0	-9.0	-10.1	-11.1	-12.1	-12.8	-13.4	-14.1	-14.1	-14.1	-14.2	-14.2
4	3.2	3.8	2.8	1.9	0.9	0.0	-1.4	-2.7	-4.1	-5.1	-6.1	-7.4	-8.7	-10.0	-11.0	-12.0	-12.4	-12.8	-13.3	-13.7	-14.1
3	4.0	4.0	4.0	4.0	2.7	1.3	0.0	-1.2	-2.4	-3.6	-4.8	-6.0	-6.7	-7.3	-8.0	-10.0	-10.7	-11.3	-12.0	-12.1	-12.1
2	3.7	4.2	3.5	2.8	2.1	1.4	0.7	0.0	-0.7	-1.3	-2.0	-3.3	-4.7	-6.0	-6.7	-7.3	-8.0	-8.5	-9.0	-9.5	-10.0
1	4.2	4.1	4.1	4.0	2.0	1.7	1.3	1.0	0.7	0.3	0.0	-2.0	-4.0	-4.5	-5.1	-5.6	-6.1	-6.6	-7.2	-7.7	-8.2

Table 2A-3(a) Wind Speed in Direction of Frontal Motion, W_x

Case 3(C) Series No. 1731,

$\bar{W}_x$ = 8.6 m s^{-1}, Length of Field L = 5714.4 m, Horizontal Increment Δx = 142.86 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	12.1	12.4	12.7	12.7	12.8	12.9	13.0	12.9	12.9	12.8	12.8	12.7	12.8	12.9	12.9	13.0	13.1	12.9	12.7	12.5	11.5
10	12.2	12.5	12.7	12.8	12.8	12.9	12.9	12.8	12.7	12.6	12.6	12.6	12.6	12.6	12.7	12.8	12.9	13.0	12.8	12.6	11.8
9	12.3	12.6	12.9	12.9	12.9	12.9	12.7	12.6	12.4	12.3	12.2	12.0	11.9	12.2	12.4	12.7	12.9	12.7	12.5	12.3	12.1
8	12.4	12.7	12.9	12.8	12.8	12.7	12.6	12.3	12.1	11.8	11.5	11.8	12.0	12.3	12.5	12.6	12.7	12.7	12.8	12.4	11.9
7	12.3	12.7	12.7	12.8	12.8	12.5	12.1	11.8	11.4	11.4	11.4	11.3	11.3	11.6	12.0	12.3	12.6	12.7	12.7	12.8	12.2
6	12.0	12.3	12.6	12.6	12.6	12.1	11.7	11.2	11.1	10.9	10.8	10.6	10.9	11.2	11.5	11.8	12.0	12.2	12.4	12.6	12.2
5	11.3	11.6	11.6	11.5	11.5	11.4	11.0	10.6	10.6	10.6	10.6	10.6	10.9	11.2	11.5	11.6	11.6	11.7	11.8	11.8	11.9
4	10.8	11.0	11.2	11.1	11.0	10.9	10.5	10.2	9.8	10.1	10.3	10.6	10.8	11.0	11.2	11.4	11.4	11.4	11.3	11.3	11.3
3	8.8	9.8	10.1	10.3	10.6	10.3	10.0	9.6	9.3	9.7	10.2	10.6	10.6	10.7	10.7	10.7	10.9	11.1	11.2	11.4	11.2
2	7.6	8.1	8.6	8.2	7.8	8.0	8.2	8.4	8.6	9.3	10.0	10.7	10.7	10.6	10.6	10.5	10.5	10.4	10.5	10.5	10.6
1	7.3	7.6	7.9	8.1	7.4	6.6	6.9	7.1	7.4	8.7	9.9	10.4	10.8	10.6	10.3	10.4	10.5	10.5	10.6	10.6	10.6

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	11.5	10.5	9.4	8.4	5.6	2.8	2.7	2.5	2.4	2.3	2.2	2.0	1.9	1.7	1.4	1.2	0.9	0.8	0.8	0.7	0.6
10	11.8	11.0	10.2	8.6	6.4	4.2	3.4	2.6	2.5	2.4	2.3	2.1	1.8	1.6	1.4	1.1	0.9	0.8	0.7	0.6	0.5
9	12.1	11.4	10.6	9.1	6.6	4.6	4.1	3.6	3.1	2.6	2.4	2.3	2.1	1.8	1.5	1.2	0.9	0.6	0.5	0.4	0.3
8	11.9	11.5	10.8	10.0	7.8	5.6	4.4	3.9	3.3	3.0	2.6	2.3	2.0	1.7	1.4	1.1	0.7	0.4	0.3	0.3	0.2
7	12.2	11.6	11.0	10.6	8.6	6.6	5.5	4.4	3.9	3.4	2.9	2.6	2.2	1.9	1.5	1.2	0.8	0.6	0.5	0.3	0.1
6	12.2	11.7	11.3	10.4	9.5	8.6	6.4	5.4	4.4	3.9	3.3	2.8	2.5	2.1	1.8	1.4	1.1	0.9	0.6	0.4	0.1
5	11.9	11.6	11.3	10.9	10.6	9.1	7.6	6.0	5.2	4.5	3.7	3.2	2.6	2.2	1.8	1.4	1.2	0.9	0.7	0.4	0.2
4	11.3	11.2	11.1	10.9	10.8	9.7	8.6	6.6	5.6	4.5	3.9	3.4	2.8	2.3	1.8	1.3	0.8	0.7	0.6	0.4	0.3
3	11.2	11.0	10.8	10.7	10.5	10.4	9.1	7.7	6.2	4.7	4.2	3.6	3.1	2.6	2.1	1.6	1.1	0.6	0.5	0.5	0.4
2	10.6	10.6	10.6	10.5	10.5	9.8	9.0	8.3	6.6	5.5	4.3	3.7	3.0	2.4	2.1	1.8	1.4	1.1	0.8	0.7	0.5
1	10.6	10.5	10.4	10.3	10.2	9.7	9.1	8.6	7.0	5.4	4.6	3.7	3.1	2.6	2.0	1.8	1.6	1.4	1.2	1.0	0.8

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Table 2A-3(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 3(C) Series No. 1731,

$\overline{W}_x = 8.6$ m s^{-1}, Length of Field L = 5714.4 m, Horizontal Increment Δx = 142.86 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.2	-1.2	-1.3	-1.3	-1.3	-1.3	-1.3	-1.4	-1.5	-1.7	-1.9	-2.0	-2.0	-2.1	-2.2	-2.0	-1.9	-1.4	-1.0	-0.8	-0.6
10	-1.0	-1.1	-1.1	-1.1	-1.2	-1.2	-1.3	-1.4	-1.5	-1.7	-1.8	-1.9	-2.1	-2.2	-2.0	-1.8	-1.6	-1.2	-0.9	-0.6	-0.4
9	-1.0	-1.0	-1.0	-1.1	-1.1	-1.1	-1.0	-1.0	-1.2	-1.4	-1.5	-1.7	-1.9	-1.7	-1.5	-1.2	-1.0	-0.9	-0.7	-0.6	-0.5
8	-0.9	-1.0	-1.1	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9	-1.1	-1.2	-1.4	-1.3	-1.2	-1.1	-1.0	-0.8	-0.6	-0.5	-0.5	-0.4
7	-0.9	-0.9	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8	-0.9	-0.9	-1.0	-1.0	-1.1	-1.0	-0.8	-0.7	-0.5	-0.5	-0.5	-0.5	-0.5
6	-0.7	-0.8	-0.8	-0.8	-0.8	-0.8	-0.7	-0.7	-0.6	-0.7	-0.8	-0.8	-0.9	-0.7	-0.6	-0.4	-0.3	-0.2	0.0	-0.2	-0.4
5	-0.6	-0.6	-0.6	-0.7	-0.7	-0.6	-0.5	-0.4	-0.5	-0.6	-0.6	-0.6	-0.7	-0.5	-0.4	-0.2	-0.1	-0.1	-0.2	-0.3	-0.4
4	-0.6	-0.6	-0.6	-0.5	-0.4	-0.4	-0.3	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.5	-0.3	-0.2	0.0	0.0	-0.1	-0.1	-0.2
3	-0.6	-0.5	-0.4	-0.4	-0.3	-0.3	-0.2	-0.1	-0.1	-0.2	-0.3	-0.4	-0.6	-0.4	-0.3	-0.1	0.0	0.0	0.0	-0.1	-0.3
2	-0.6	-0.4	-0.4	-0.3	-0.3	-0.2	-0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.3	-0.2	-0.1	-0.1	0.0	-0.1	-0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.6	-0.2	0.1	0.5	3.0	4.1	4.1	4.0	3.0	2.0	1.7	1.3	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.3
10	-0.4	-0.1	0.1	0.4	2.0	3.1	4.0	3.2	2.4	2.0	1.5	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2
9	-0.5	-0.2	0.0	0.2	1.2	2.9	3.4	3.0	2.3	1.6	1.3	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2
8	-0.4	-0.4	-0.2	0.0	1.0	2.0	3.0	2.5	2.1	1.6	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.2
7	-0.5	-0.5	-0.2	0.2	0.5	1.2	2.4	2.7	2.9	1.9	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.1
6	-0.4	-0.6	-0.4	-0.2	0.0	1.0	2.0	1.7	1.4	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.1
5	-0.4	-0.5	-0.3	-0.1	0.2	0.4	1.2	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.1	0.0
4	-0.2	-0.3	-0.4	-0.1	0.3	0.6	1.0	1.0	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.1	-0.1
3	-0.3	-0.4	-0.6	-0.4	-0.2	0.0	0.5	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.1	0.0	-0.1
2	-0.2	-0.4	-0.5	-0.3	-0.2	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.4	0.3	0.2	0.2	0.1	0.0	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2A-3(c) Vertical Wind Speed, W_z

Case 3(C) Series No. 1731,

$\overline{W}_x = 8.6\ m\ s^{-1}$, Length of Field L = 5714.4 m, Horizontal Increment Δx = 142.86 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	-1.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
10	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.8	-1.4	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0
9	-1.0	-0.9	-0.7	-0.6	-0.5	-0.6	-0.7	-0.9	-1.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0
8	-1.7	-1.5	-1.2	-1.0	-0.8	-1.0	-1.2	-1.5	-1.7	-1.9	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-2.1	-2.1	-2.1	-2.0	-2.0
7	-2.0	-1.8	-1.6	-1.4	-1.2	-1.4	-1.6	-1.8	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-2.2	-2.1	-2.1	-2.0	-2.0	-1.9	-1.8
6	-2.0	-1.8	-1.5	-1.3	-1.5	-1.6	-1.8	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-2.2	-2.1	-2.0	-2.0	-1.9	-1.9	-1.8	-1.7
5	-2.0	-1.8	-1.5	-1.3	-1.5	-1.8	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.9	-1.8	-1.9	-1.9
4	-2.0	-1.8	-1.7	-1.5	-1.8	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.8	-1.6	-1.8	-2.0	-2.0
3	-2.0	-1.9	-1.8	-1.7	-1.9	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0	-1.8	-1.5	-1.8	-2.0	-2.0	-2.0
2	-1.8	-1.9	-1.9	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-2.0	-1.9	-1.8	-1.6	-1.5	-1.8	-2.0	-2.0	-2.0	-2.0
1	-1.5	-1.6	-1.8	-1.9	-2.0	-1.5	-1.8	-2.1	-2.0	-1.8	-1.9	-2.0	-1.9	-1.8	-1.6	-1.5	-1.7	-1.9	-2.1	-2.1	-2.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-2.0	-2.0	-1.0	0.0	1.0	2.0	2.5	3.0	3.5	4.0	4.0	4.0	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2
10	-2.0	-2.0	-1.0	0.0	0.9	1.9	2.5	3.0	3.5	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.2	4.2
9	-2.0	-1.5	-0.9	-0.4	0.1	1.1	2.2	2.8	3.5	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
8	-2.0	-1.5	-1.0	-0.5	0.0	1.0	2.1	2.8	3.4	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
7	-1.8	-1.7	-1.6	-1.5	-0.7	0.0	2.0	2.7	3.4	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3
6	-1.7	-1.8	-1.9	-2.0	-1.0	0.0	1.1	2.2	3.1	4.0	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.3	4.3	4.3
5	-1.9	-2.0	-2.0	-2.0	-2.0	-0.8	0.4	1.3	2.2	3.1	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.2
4	-2.0	-2.0	-2.0	-2.0	-2.0	-1.0	0.0	1.0	2.1	2.3	2.6	2.8	3.0	3.3	3.5	3.8	4.0	4.0	4.1	4.1	4.1
3	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.0	0.0	2.0	2.3	2.5	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.0	4.1	4.1
2	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	1.0	1.5	2.0	2.1	2.1	2.2	2.2	2.3	2.5	2.8	3.0	3.3	3.5
1	-2.0	-2.0	-1.4	-1.6	-1.8	-2.0	-1.3	-0.7	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.2	2.5	2.7	3.0	3.2

Table 2Λ-4(a) Wind Speed in Direction of Frontal Motion, W_x

Case 4(D) Series No. 1459,

$\bar{W}_x$ = 11.6 m s^{-1}, Length of Field L = 7692.4 m, Horizontal Increment x = 192.31 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	14.1	14.6	15.1	15.6	15.6	15.6	15.6	15.1	15.6	15.5	15.4	15.3	15.1	15.0	14.9	14.8	14.7	14.5	14.4	14.3	14.2
10	13.8	14.2	14.5	14.9	15.2	15.6	15.2	14.8	15.2	15.6	15.5	15.4	15.3	15.1	15.0	14.9	14.8	14.6	14.5	14.3	14.2
9	13.7	14.2	14.6	15.1	15.5	15.5	15.5	15.6	15.6	15.6	15.5	15.5	15.4	15.4	15.3	15.3	15.2	15.0	14.8	14.7	14.5
8	13.7	14.1	14.6	15.0	15.4	15.3	15.1	15.0	15.2	15.4	15.6	15.5	15.4	15.2	15.1	15.3	15.4	15.2	15.0	14.7	14.5
7	13.7	14.3	14.9	15.5	15.5	15.5	15.4	15.2	15.1	15.3	15.4	15.6	15.4	15.3	15.1	15.4	15.6	15.3	15.0	14.7	14.5
6	13.8	14.4	15.0	15.6	15.4	15.6	15.5	15.4	15.2	15.1	15.3	15.4	15.6	15.4	15.1	15.4	15.7	15.6	15.1	14.5	14.0
5	14.0	14.8	15.6	15.3	15.0	15.3	15.6	15.5	15.3	15.4	15.5	15.5	15.6	15.4	15.1	15.5	15.8	15.6	14.6	14.1	13.6
4	14.1	15.6	15.3	15.0	14.7	15.0	15.3	15.6	15.4	15.5	15.5	15.6	15.4	15.2	15.0	15.4	15.7	15.0	14.2	13.5	11.9
3	15.8	12.1	12.7	13.2	13.8	14.0	14.1	14.8	15.4	14.5	13.6	13.6	13.6	13.6	13.6	14.1	14.5	13.6	12.6	11.1	11.3
2	15.5	11.6	12.2	12.8	13.4	13.5	13.6	13.9	14.1	12.9	11.6	11.7	11.7	11.8	11.9	12.0	10.8	9.6	8.6	7.6	8.6
1	15.1	11.6	11.6	11.6	11.6	11.6	11.6	13.6	13.6	11.6	10.6	9.5	9.6	11.6	11.8	11.9	9.6	8.6	7.6	7.3	7.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	14.2	14.1	14.0	13.8	13.7	13.6	9.7	5.7	1.8	1.1	0.3	-0.4	-0.7	-1.0	-1.3	-1.5	-1.8	-2.1	-2.4	-2.5	-2.6
10	14.2	14.0	13.9	13.7	13.6	13.4	10.5	7.5	4.6	1.6	0.9	0.2	-0.5	-0.8	-1.1	-1.4	-1.6	-1.9	-2.2	-2.5	-2.6
9	14.5	14.3	14.1	14.0	13.8	13.6	10.3	6.9	3.6	2.6	1.7	0.7	-0.3	-0.6	-0.9	-1.2	-1.5	-1.8	-2.1	-2.4	-2.5
8	14.5	14.3	14.1	13.8	13.6	11.6	9.6	7.6	5.0	2.3	1.6	1.0	0.3	-0.4	-0.7	-1.1	-1.4	-1.7	-2.1	-2.4	-2.5
7	14.5	14.2	13.9	13.6	12.6	11.6	10.6	8.0	5.3	3.6	1.8	1.2	0.5	0.0	-0.5	-1.1	-1.6	-1.9	-2.2	-2.5	-2.6
6	14.0	13.8	13.5	12.9	12.2	11.6	10.1	8.6	6.5	4.4	3.0	1.5	0.9	0.2	-0.4	-0.9	-1.3	-1.8	-2.3	-2.5	-2.7
5	13.6	13.1	12.6	12.0	11.3	10.7	10.2	9.6	7.6	5.6	3.5	2.4	1.2	0.5	-0.3	-0.8	-1.3	-1.8	-2.3	-2.5	-2.7
4	11.9	11.8	11.7	11.6	11.0	10.5	9.9	9.3	8.0	6.6	5.0	3.4	2.3	1.1	0.2	-0.7	-1.1	-1.5	-1.9	-2.3	-2.7
3	11.3	11.4	11.6	10.7	9.8	9.7	9.6	8.9	8.3	7.6	5.6	4.6	3.6	2.6	1.6	0.5	-0.6	-1.0	-1.5	-1.9	-2.4
2	8.6	9.6	9.6	9.5	9.5	9.0	8.6	8.1	7.6	7.1	6.6	6.1	5.6	4.6	3.6	1.9	0.1	-0.3	-0.7	-1.1	-1.5
1	7.5	7.7	8.0	8.3	8.6	8.1	7.6	7.6	7.5	7.5	7.6	7.6	7.6	6.6	5.6	3.6	1.6	1.1	0.6	0.1	-0.4

Table 2A-4(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 4(D) Series No. 1459,

$\overline{W}_x = 11.6\ m\ s^{-1}$, Length of Field L = 7692.4 m, Horizontal Increment Δx = 192.31 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	1.1	1.1	1.2	1.2	1.1	1.1	1.0	1.0	0.9	1.0	1.2	1.3	1.0	0.9	0.9	1.0	1.1	1.2	1.2	1.3	1.4
10	1.1	1.2	1.2	1.3	1.2	1.1	1.1	1.0	0.9	1.0	1.1	1.2	1.0	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.3
9	1.0	1.1	1.3	1.4	1.3	1.2	1.1	1.0	0.9	1.0	1.1	1.2	1.0	0.9	0.8	1.0	1.1	1.1	1.2	1.3	1.1
8	0.9	1.1	1.2	1.4	1.3	1.2	1.1	1.0	0.8	0.9	1.1	1.0	1.0	0.9	0.8	1.0	1.1	1.1	1.2	1.3	1.1
7	0.8	1.1	1.2	1.3	1.2	1.1	1.1	1.0	0.8	0.9	0.9	1.0	1.0	0.9	0.8	0.9	0.9	1.0	1.1	1.2	1.0
6	0.7	1.0	1.1	1.3	1.2	1.1	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9	1.0	1.2	1.0
5	0.6	0.8	1.0	1.2	1.1	1.0	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1.1	0.9
4	0.5	0.7	0.8	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.6	0.8	0.6
3	0.4	0.5	0.6	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.3	0.2	0.1	0.0	0.1	0.1	0.2	0.2
2	0.3	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	-0.1	0.0	0.1	0.1	0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	1.4	1.3	1.2	1.1	1.0	0.9	1.9	3.5	5.1	5.2	5.0	4.0	3.3	2.7	2.0	1.8	1.5	1.2	1.0	0.8	0.6
10	1.3	1.2	1.2	1.1	1.1	1.0	1.5	3.0	4.5	5.0	4.4	3.8	3.0	2.6	2.2	1.8	1.4	1.0	0.8	0.7	0.5
9	1.1	1.0	1.1	1.2	1.0	0.9	1.3	2.5	4.1	4.0	3.9	3.4	2.9	2.3	1.8	1.5	1.2	0.9	0.8	0.6	0.5
8	1.1	0.9	1.0	1.2	1.0	0.9	1.5	2.0	2.8	3.5	3.3	3.1	2.5	2.0	1.7	1.3	1.0	0.9	0.7	0.6	0.5
7	1.0	0.9	0.9	1.0	1.1	0.8	1.0	1.8	2.6	2.8	3.0	2.6	2.2	1.8	1.4	1.0	0.9	0.8	0.6	0.5	0.4
6	1.0	0.8	0.9	1.0	0.9	0.8	1.1	1.5	2.0	2.3	2.5	2.3	2.0	1.6	1.3	0.9	0.8	0.7	0.5	0.4	0.3
5	0.9	0.6	0.7	0.8	0.9	0.9	1.0	1.0	1.3	1.7	2.0	2.1	1.9	1.7	1.5	1.3	1.1	0.9	0.7	0.5	0.3
4	0.6	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.2	1.3	1.5	1.2	1.0	0.9	0.8	0.7	0.5	0.4	0.3	0.2
3	0.2	0.2	0.3	0.3	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2
2	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.3	0.2	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-4(c) Vertical Wind Speed, W_z

Case 4(D) Series No. 1459,

$\overline{W}_x = 11.6\ m\ s^{-1}$, Length of Field L = 7692.4 m, Horizontal Increment Δx = 192.31 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-2.7	-2.5	-2.2	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0
10	-2.8	-2.6	-2.4	-2.2	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.8	-1.6	-1.5	-1.3	-1.1	-0.9	-0.7	-0.6	-0.4	-0.2
9	-3.0	-2.8	-2.5	-2.3	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.9	-0.7	-0.5	-0.3	-0.1
8	-3.5	-3.2	-2.9	-2.6	-2.3	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2
7	-3.9	-3.6	-3.4	-3.1	-2.9	-2.6	-2.4	-2.1	-2.1	-2.2	-2.2	-2.1	-2.0	-1.8	-1.6	-1.3	-1.1	-0.9	-0.7	-0.4	-0.2
6	-4.0	-3.8	-3.6	-3.4	-3.2	-3.2	-3.2	-3.2	-3.2	-3.0	-2.7	-2.5	-2.2	-2.0	-1.8	-1.5	-1.2	-1.0	-0.7	-0.5	-0.2
5	-4.0	-4.0	-3.9	-3.7	-3.4	-3.5	-3.7	-3.8	-3.9	-3.6	-3.3	-3.0	-2.6	-2.3	-2.0	-1.8	-1.5	-1.3	-1.0	-0.8	-0.6
4	-4.0	-4.0	-4.0	-3.9	-3.9	-3.9	-3.9	-4.0	-4.0	-4.0	-3.7	-3.3	-3.0	-2.7	-2.3	-2.0	-1.7	-1.4	-1.1	-0.9	-0.6
3	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.7	-3.4	-3.1	-2.9	-2.6	-2.3	-2.0	-1.7	-1.3	-1.0	-0.7
2	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-3.7	-3.5	-3.3	-3.0	-2.8	-2.5	-2.3	-2.0	-1.6	-1.2	-0.8	-0.4
1	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.6	-2.4	-2.2	-2.0	-1.5	-1.0	-0.5	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.1	6.1	6.2
10	-0.2	0.0	0.0	0.0	0.4	0.8	1.3	1.7	2.1	2.5	2.9	3.4	3.8	4.2	4.5	4.9	5.2	5.6	5.9	6.1	6.2
9	-0.1	-0.1	-0.1	0.0	0.0	0.5	0.9	1.4	1.9	2.3	2.7	3.2	3.6	4.0	4.3	4.6	4.9	5.1	5.4	5.7	6.0
8	-0.2	0.0	-0.1	0.1	0.3	0.6	0.8	1.1	1.5	1.8	2.3	2.8	3.2	3.7	3.9	4.2	4.4	4.6	4.8	5.1	5.3
7	-0.2	0.0	0.0	0.0	0.2	0.5	0.4	0.4	0.3	1.1	1.9	2.4	2.9	3.4	3.9	4.1	4.3	4.4	4.6	4.8	5.0
6	-0.2	0.0	0.0	0.0	0.2	0.3	0.2	0.1	0.0	0.6	1.3	1.9	2.3	2.6	3.0	3.3	3.7	4.0	4.2	4.3	4.5
5	-0.6	-0.3	-0.1	0.1	0.2	0.1	0.1	0.0	-0.1	0.4	0.9	1.4	1.9	2.2	2.4	2.7	3.0	3.2	3.5	3.7	4.0
4	-0.6	-0.3	0.0	0.0	0.0	0.0	-0.2	-0.5	-0.7	-1.0	-0.5	0.0	0.7	1.3	2.0	2.2	2.3	2.5	2.7	2.8	3.0
3	-0.7	-0.3	0.0	0.0	0.0	-0.5	-1.0	-1.5	-2.0	-2.0	-2.0	-1.0	0.0	0.5	1.0	1.5	2.0	2.0	2.1	2.2	2.2
2	-0.4	0.0	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.7	-3.3	-4.0	-3.0	-2.0	-1.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
1	0.0	0.0	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.0	-2.0	-1.7	-1.3	-1.0	-0.7	-0.3	0.0

Table 2A-5(a) Wind Speed in Direction of Frontal Motion, W_x

Case 5(E) Series No. 1924,

$\overline{W}_x$ =16.7 m s^{-1}, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	25.4	25.6	25.8	26.1	26.3	26.5	26.7	26.9	26.7	26.2	25.7	25.1	24.6	24.3	24.1	23.8	23.6	23.4	23.1	22.9	23.0
10	25.1	25.0	25.0	24.9	24.8	25.1	25.5	25.8	25.6	25.4	25.2	25.0	24.6	24.2	23.8	23.5	23.3	23.0	22.7	22.6	22.5
9	24.7	24.5	24.2	24.0	23.7	24.4	25.0	25.0	25.0	24.9	24.9	24.6	24.3	24.0	23.7	23.4	23.1	22.8	21.8	20.8	21.4
8	24.7	23.7	22.7	22.4	22.0	22.7	23.8	24.0	24.2	24.3	24.5	24.3	24.1	23.9	23.7	23.4	23.0	22.7	21.2	19.7	20.2
7	22.7	22.0	21.4	20.7	20.8	20.8	21.3	21.8	22.3	22.6	22.9	23.0	23.2	23.3	23.4	23.1	22.8	21.0	19.1	18.7	19.7
6	20.7	20.2	19.7	19.5	19.2	19.5	19.7	20.1	20.5	21.2	22.0	22.7	22.8	22.8	22.9	22.8	22.6	20.6	19.6	18.5	19.1
5	18.7	18.6	18.5	18.5	18.5	18.6	18.6	18.6	18.6	19.7	20.8	21.2	21.7	22.1	22.5	21.7	20.8	19.3	17.7	18.1	18.4
4	15.2	16.0	16.7	16.5	16.4	16.2	15.7	16.1	16.5	16.9	19.0	19.9	20.7	20.6	20.6	20.5	18.7	18.0	17.2	16.7	17.3
3	12.6	13.7	14.7	14.8	14.8	13.9	12.9	13.7	14.5	16.6	17.7	18.8	18.8	18.7	18.7	17.7	16.6	16.5	16.3	16.2	16.7
2	10.7	11.4	12.0	12.7	12.6	12.5	11.7	10.8	11.9	12.9	13.2	13.5	13.2	12.8	12.5	13.1	13.6	14.2	14.7	16.7	17.1
1	10.2	10.4	10.7	12.7	12.7	10.7	9.5	8.9	10.2	12.7	12.9	12.9	12.7	12.6	11.5	10.4	11.5	12.6	13.8	15.0	15.8

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	23.0	23.0	22.9	22.7	20.7	16.7	12.7	8.7	7.7	6.7	6.0	5.4	4.7	2.7	2.2	1.7	1.2	0.7	0.4	0.5	0.6
10	22.5	22.7	22.9	22.0	21.0	17.7	13.7	10.4	9.1	7.8	6.5	5.7	4.9	3.9	2.8	2.3	1.7	1.2	0.6	0.7	0.7
9	21.4	22.0	22.6	21.8	21.0	18.7	14.7	11.0	9.1	7.9	6.9	6.0	5.1	4.3	3.5	2.7	2.1	1.5	0.9	1.2	1.5
8	20.2	20.8	21.3	21.8	19.1	17.9	16.7	12.8	10.7	8.8	7.5	6.4	5.2	4.5	3.8	3.1	2.4	2.0	1.5	1.6	1.7
7	19.7	20.7	20.9	21.1	21.3	20.5	17.7	14.7	12.5	10.4	8.0	6.7	5.4	4.7	4.0	3.2	2.5	2.3	2.1	2.2	2.3
6	19.1	19.7	20.2	20.8	20.9	20.8	19.1	16.7	13.4	10.5	8.4	7.0	5.5	4.8	4.1	3.4	2.7	2.5	2.2	2.4	2.5
5	18.4	18.7	19.1	20.1	21.0	21.1	20.6	17.7	14.5	10.6	8.5	6.4	5.8	5.2	4.6	3.9	3.3	2.7	2.7	2.6	2.6
4	17.3	17.8	18.4	19.7	20.9	20.8	20.7	15.7	14.7	10.7	8.6	6.5	4.6	2.7	2.7	2.6	2.6	2.5	2.5	2.4	2.4
3	16.7	17.3	17.8	18.8	19.9	20.9	18.8	16.7	13.7	10.6	8.4	6.2	5.3	4.4	4.1	3.9	3.6	3.3	3.0	2.8	2.5
2	17.1	17.6	18.0	18.5	18.9	17.9	16.8	14.5	12.2	9.7	7.2	5.9	4.5	4.0	3.6	3.1	2.6	2.6	2.5	2.5	2.4
1	15.8	16.5	16.6	16.8	16.9	16.8	14.5	12.2	10.6	8.5	6.4	5.1	3.8	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4

Table 2A-5(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 5(E) Series No. 1924,

$\overline{W}_x = 16.7 \text{ m s}^{-1}$, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	1.1	1.1	1.0	1.0	1.0	0.5	0.0	-1.0	0.5	2.0	-2.2	-2.0	-1.0	-0.8	-0.9	-1.1	-1.2	-0.9	-0.5	0.2	0.0
10	1.2	1.0	0.8	0.6	0.4	0.2	-0.4	-1.0	-1.3	-1.7	-2.0	-1.5	-0.9	-1.0	-1.1	-1.1	-1.0	-1.0	-0.4	0.1	-0.1
9	1.1	0.9	0.7	0.5	0.3	0.1	-0.4	-1.0	-1.1	-1.0	-1.2	-1.5	-0.9	-0.9	-1.0	-1.2	-1.1	-1.0	-0.5	0.0	-0.1
8	1.1	0.4	0.5	0.5	0.6	0.1	-0.4	-1.0	-1.0	-0.9	-1.2	-1.3	-0.9	-0.9	-1.0	-1.2	-1.1	-1.0	-0.6	-0.1	-0.1
7	1.0	0.0	0.2	0.4	0.2	0.1	-0.5	-1.0	-0.9	-0.9	-1.0	-1.2	-0.9	-0.9	-1.0	-1.2	-1.1	-0.9	-0.6	-0.4	-0.2
6	0.7	-0.1	0.0	0.2	0.3	0.1	-0.4	-0.9	-0.9	-0.8	-0.9	-1.1	-0.9	-1.0	-1.0	-1.1	-1.0	-0.9	-0.7	-0.5	-0.3
5	0.4	-0.1	0.0	0.1	0.2	0.0	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.0	-1.1	-1.2	-1.1	-1.0	-1.1	-1.2	-1.3	-1.1
4	0.3	-0.2	-0.1	0.0	0.2	0.1	-0.1	-0.3	-0.4	-0.6	-0.8	-1.2	-1.2	-1.1	-1.1	-1.1	-1.0	-0.6	-0.3	-0.3	-0.2
3	0.0	-0.1	-0.2	-0.1	0.0	0.0	-0.2	-0.3	-0.5	-0.6	-0.8	-1.1	-1.1	-1.1	-1.1	-1.1	-0.8	-0.4	0.0	-0.1	-0.1
2	0.0	-0.1	-0.2	-0.2	-0.1	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.3	0.0	0.0	-0.1	-0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.0	-0.2	-0.1	0.0	1.0	3.0	5.1	5.2	5.0	4.0	3.0	2.5	2.0	1.5	1.0	0.9	0.9	0.9	0.8	0.7	0.7
10	-0.1	-0.2	-0.1	0.0	0.8	2.5	4.5	5.0	4.7	3.5	2.6	2.1	1.6	1.2	1.1	1.1	1.0	1.0	0.9	0.9	0.8
9	-0.1	-0.2	-0.1	0.0	0.8	2.0	3.5	4.1	4.0	3.0	2.0	1.7	1.3	1.0	0.8	0.6	0.5	0.3	0.5	0.7	0.9
8	-0.1	-0.2	-0.2	0.2	0.5	1.5	2.5	3.5	3.8	3.0	1.8	1.2	0.8	0.6	0.4	0.3	0.1	0.0	0.3	0.7	1.0
7	-0.2	-0.2	-0.1	-0.1	0.0	1.0	1.7	2.5	3.0	2.4	1.5	0.9	0.7	0.5	0.3	0.2	0.0	-0.1	0.0	0.6	1.1
6	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.7	1.5	2.3	2.0	1.4	0.7	0.6	0.4	0.3	0.2	0.1	-0.1	0.0	0.5	1.0
5	-1.1	-0.9	-0.7	-0.6	-0.4	-0.2	0.0	1.0	1.4	1.8	1.1	0.5	0.2	0.0	0.1	0.1	-0.1	-0.2	0.0	0.5	1.0
4	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.5	1.0	0.6	0.3	-0.1	0.0	0.1	0.0	-0.1	-0.2	0.0	0.2	0.6
3	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.4	0.8	0.4	0.0	-0.1	0.0	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.5
2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.2	0.5	0.2	-0.2	-0.1	0.0	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-5(c) Vertical Wind Speed, W_z

Case 5(E) Series No. 1924,

$\overline{W}_x = 16.7 \text{ m s}^{-1}$, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-6.5	-6.4	-6.2	-6.1	-6.0	-5.7	-5.5	-5.2	-4.9	-4.7	-4.4	-4.2	-3.9	-3.7	-3.4	-3.2	-3.0	-2.7	-2.5	-2.2	-2.0
10	-6.5	-6.0	-5.6	-5.2	-5.1	-4.9	-4.8	-4.7	-4.5	-4.4	-4.3	-4.1	-4.0	-3.7	-3.4	-3.1	-2.9	-2.6	-2.3	-2.0	-1.1
9	-6.5	-6.0	-5.4	-4.8	-4.7	-4.7	-4.6	-4.6	-4.5	-4.4	-4.4	-4.3	-4.2	-4.0	-3.7	-3.3	-3.0	-2.7	-2.3	-2.0	-1.0
8	-6.2	-5.5	-4.7	-4.0	-4.1	-4.1	-4.2	-4.1	-4.0	-4.1	-4.1	-4.2	-4.1	-4.0	-3.7	-3.3	-3.0	-2.6	-2.3	-1.9	-0.9
7	-6.0	-4.9	-3.9	-3.9	-4.0	-4.0	-4.0	-3.9	-3.8	-3.9	-4.0	-4.0	-4.0	-3.7	-3.3	-3.0	-2.7	-2.3	-2.0	-1.0	0.0
6	-5.0	-4.0	-3.8	-3.6	-3.4	-3.2	-3.0	-2.8	-2.9	-2.9	-3.0	-3.0	-3.1	-2.9	-2.7	-2.4	-2.2	-2.0	-1.3	-0.6	0.1
5	-4.0	-3.7	-3.4	-3.0	-2.7	-2.4	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-1.5	-1.0	-0.4	0.1
4	-2.0	-2.0	-1.9	-1.9	-1.9	-1.8	-1.8	-1.9	-2.0	-2.1	-2.2	-2.3	-2.4	-2.5	-2.3	-2.2	-2.0	-1.3	-0.7	0.0	0.2
3	-0.9	-1.2	-1.5	-1.8	-2.1	-1.5	-1.0	-1.2	-1.5	-1.8	-2.0	-2.1	-2.2	-2.1	-2.1	-2.0	-1.3	-0.7	0.0	0.0	0.0
2	0.0	-0.1	-0.2	-0.4	-0.5	-0.2	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.0	-2.0	-2.0	-1.3	-0.7	0.0	-0.1	-0.2	0.3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.0	-2.0	-1.3	-0.7	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-2.0	-1.0	0.0	1.8	2.7	3.5	4.4	5.2	6.1	6.6	7.1	7.5	8.0	8.1	8.1	8.2	8.1	8.1	8.1	8.0	7.0
10	-1.1	-0.2	0.8	1.8	2.6	3.5	4.3	5.2	6.0	6.4	6.8	7.3	7.7	8.1	8.1	8.1	8.0	8.0	8.0	7.2	6.3
9	-1.0	0.0	0.9	1.8	2.6	3.4	4.1	4.9	5.7	6.2	6.7	7.1	7.6	8.1	8.1	8.1	8.1	8.1	7.4	6.7	6.0
8	-0.9	0.1	0.9	1.8	2.3	2.9	3.5	4.0	5.0	6.0	6.5	7.0	7.5	8.0	8.0	8.0	8.0	7.5	6.9	6.4	5.9
7	0.0	0.6	1.2	1.8	2.2	2.7	3.1	3.6	4.0	4.6	5.3	5.9	6.5	7.1	7.7	7.4	7.0	6.7	6.4	6.0	5.7
6	0.1	0.6	1.1	1.7	2.2	2.1	2.1	2.0	3.0	4.0	4.7	5.4	6.1	6.5	6.9	6.7	6.5	6.4	6.2	6.0	5.4
5	0.1	0.5	1.0	1.5	2.0	2.0	1.9	1.9	2.1	3.1	4.1	5.0	6.0	6.1	6.1	6.1	6.0	6.0	5.7	5.3	5.0
4	0.2	0.5	0.7	1.0	0.7	0.5	0.2	0.0	1.9	2.6	3.3	4.0	4.5	4.9	5.4	5.3	5.2	5.1	5.0	4.9	4.8
3	0.0	0.0	0.6	1.1	1.7	0.9	0.0	0.7	1.5	2.1	2.8	3.4	4.0	4.1	4.2	4.3	4.3	4.4	4.5	4.3	4.0
2	0.3	0.9	1.5	2.0	2.5	3.1	1.5	0.0	1.0	2.1	2.4	2.7	3.0	3.4	3.7	4.0	4.0	4.0	4.1	4.1	4.1
1	0.0	0.0	2.0	3.0	4.0	3.0	2.0	1.9	1.8	2.1	2.3	2.6	2.9	3.2	3.5	3.7	4.0	4.0	4.1	4.1	4.1

Table 2A-6(a) Wind Speed in Direction of Frontal Motion, W_x

Case 6(F) Series No. 1933,

$\overline{W}_x = 11.0 \text{ m s}^{-1}$, Length of Field L = 7272.8 m, Horizontal Increment Δx = 181.82 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	10.3	10.5	10.8	11.0	12.0	13.0	14.0	15.0	15.0	15.1	15.1	15.1	15.1	15.2	15.2	15.1	15.1	15.0	14.6	14.2	14.6
10	10.3	10.6	11.0	11.7	12.3	13.0	14.0	14.1	14.2	14.3	14.4	14.6	14.7	14.8	14.9	15.0	15.1	14.8	14.5	14.2	14.5
9	10.3	10.7	11.1	11.8	12.5	13.2	13.4	13.4	13.4	13.3	13.3	13.5	13.7	13.8	14.0	14.0	14.0	14.1	14.1	14.1	14.3
8	10.3	10.7	11.1	11.7	12.4	13.0	13.2	13.1	12.9	12.9	12.8	13.4	14.0	13.5	13.0	13.3	13.6	13.9	13.9	13.9	14.0
7	10.2	10.6	11.0	11.4	11.9	12.4	12.8	12.8	12.9	12.9	12.9	13.1	13.3	13.0	12.8	13.0	13.2	13.1	13.0	13.1	13.1
6	10.0	10.4	10.8	11.1	11.3	11.6	11.9	12.1	12.4	12.7	12.9	13.2	13.1	12.9	12.1	12.6	13.2	13.0	12.8	12.9	12.9
5	9.9	10.4	10.8	11.3	11.5	11.7	11.9	12.1	12.2	12.4	12.6	12.8	13.0	12.4	11.8	12.4	13.0	12.9	12.8	12.6	12.5
4	9.0	9.7	10.3	11.0	11.1	11.1	11.2	11.3	11.3	11.4	11.3	11.2	11.2	11.1	11.0	11.0	11.0	11.0	10.9	10.9	10.9
3	8.0	8.5	9.0	9.3	9.7	10.0	10.3	10.7	11.0	11.0	11.1	11.1	11.1	10.4	9.8	9.7	9.6	9.5	9.4	9.3	9.2
2	7.0	7.5	7.9	8.4	8.8	8.8	8.8	8.7	8.7	8.7	8.7	7.8	7.0	6.7	6.4	6.2	5.9	5.9	5.8	5.8	5.8
1	6.7	6.7	6.8	6.8	6.8	6.9	6.9	7.0	7.0	6.3	5.7	5.0	4.9	4.9	5.0	5.0	4.3	3.7	3.0	2.9	2.9

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	14.6	15.0	15.2	15.0	14.6	14.2	13.8	13.4	13.0	9.0	5.0	1.0	-1.0	-1.3	-1.7	-2.0	-2.4	-2.7	-2.9	-3.1	-3.3
10	14.5	14.8	15.1	14.6	14.0	13.7	13.4	13.1	11.6	10.0	6.0	1.0	0.0	-1.0	-1.4	-1.9	-2.3	-2.7	-2.9	-3.1	-3.3
9	14.3	14.6	14.8	14.2	13.6	13.0	12.5	12.0	11.5	11.0	7.0	3.0	0.0	-0.6	-1.1	-1.6	-2.2	-2.7	-2.9	-3.1	-3.3
8	14.0	14.0	14.0	13.7	13.3	13.0	12.5	12.0	11.5	11.0	8.0	4.0	0.3	-0.4	-1.0	-1.6	-2.2	-2.8	-3.0	-3.1	-3.3
7	13.1	13.2	13.1	13.1	13.0	12.0	11.0	11.0	11.1	11.1	9.0	5.0	0.9	-0.1	-1.0	-1.6	-2.3	-2.9	-3.1	-3.2	-3.4
6	12.9	13.0	12.9	12.9	12.8	11.9	10.9	10.4	10.0	9.6	9.1	5.5	1.7	0.1	-1.3	-1.9	-2.4	-3.0	-3.1	-3.3	-3.4
5	12.5	12.4	12.3	12.1	12.0	11.5	11.0	10.6	10.1	9.6	9.2	7.0	3.0	0.9	-0.1	-1.2	-2.1	-2.9	-3.1	-3.2	-3.4
4	10.9	10.9	10.9	11.0	11.1	11.1	11.0	10.4	9.8	9.2	8.6	8.0	5.0	2.5	0.3	-1.0	-1.7	-2.3	-3.0	-3.1	-3.3
3	9.2	9.1	9.0	9.6	10.1	10.7	11.3	10.1	9.0	8.8	8.7	8.5	6.9	3.8	1.3	0.1	-1.2	-1.6	-2.1	-2.6	-3.0
2	5.8	5.7	5.7	6.3	7.0	7.8	8.7	8.1	7.6	7.0	7.5	8.0	6.9	5.9	3.1	1.0	0.0	-1.0	-1.3	-1.7	-2.0
1	2.9	2.9	3.0	4.9	5.6	6.3	7.0	6.3	5.7	4.9	5.0	6.0	7.0	7.2	5.0	1.7	1.2	0.6	0.1	-0.5	-1.0

Table 2A-6(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 6(F) Series No. 1933,

$\overline{W}_x = 11.0\ m\ s^{-1}$, Length of Field L = 7272.8 m, Horizontal Increment Δx = 181.82 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.0	-1.4	-1.9	-2.3	-2.2	-2.1	-2.0	-1.1	-0.9	-0.7	-0.6	-0.4	-0.2	0.0	0.2	0.4	0.6	0.9	1.1	1.2	1.0
10	-0.9	-2.0	-2.1	-2.2	-2.1	-2.0	-1.5	-1.0	-0.8	-0.6	-0.5	-0.3	-0.1	0.2	0.5	0.6	0.7	0.9	1.0	1.1	1.0
9	-0.8	-1.4	-2.0	-2.1	-2.0	-1.5	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0	0.4	0.8	0.8	0.7	0.7	0.9	1.0	0.5
8	-0.8	-1.2	-1.5	-1.7	-1.4	-1.1	-0.9	-0.8	-0.6	-0.4	-0.3	-0.1	0.3	0.6	1.0	1.0	0.9	0.9	0.8	0.8	0.4
7	-0.7	-1.0	-1.2	-1.5	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	0.2	0.4	0.7	0.9	1.1	1.0	0.9	0.9	0.8	0.7	0.3
6	-0.5	-0.7	-1.0	-1.1	-1.0	-0.7	-0.4	-0.1	-0.1	-0.2	-0.2	0.0	0.4	0.8	1.2	1.1	0.8	0.6	0.5	0.3	0.2
5	-0.4	-0.5	-0.7	-0.8	-0.5	-0.3	0.0	0.0	0.0	-0.1	-0.1	0.2	0.5	0.9	1.2	1.0	0.8	0.6	0.5	0.3	0.2
4	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.1	0.1	0.0	0.3	0.6	0.8	1.1	1.0	0.7	0.5	0.2	0.0	-0.1
3	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.6	0.8	1.0	0.9	0.7	0.6	0.5	0.4	0.2
2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	1.0	0.0	-1.1	-1.0	0.2	1.0	1.1	1.1	0.8	1.0	4.0	5.1	6.1	5.6	5.0	3.0	2.0	1.7	1.3	1.0	0.8
10	1.0	0.0	-1.0	-0.9	0.1	0.6	1.0	1.0	0.8	1.0	3.0	5.0	5.8	5.0	4.0	3.0	1.9	1.5	1.0	0.9	0.7
9	0.5	0.0	-0.9	-0.4	0.0	0.4	0.9	0.8	0.9	1.0	2.7	4.1	5.0	4.4	3.8	2.8	1.8	1.4	0.9	0.8	0.7
8	0.4	0.0	-0.3	-0.6	0.0	0.2	0.5	0.7	1.0	1.4	2.5	3.5	4.2	4.3	3.5	2.4	1.6	1.0	0.9	0.7	0.6
7	0.3	0.0	-0.2	-0.5	-0.3	-0.2	0.0	0.5	1.0	1.5	2.0	2.8	3.5	3.8	3.0	2.0	1.5	1.0	0.9	0.7	0.6
6	0.2	0.0	-0.1	-0.3	-0.4	-0.2	0.0	0.6	1.1	1.4	1.7	2.0	2.5	3.1	2.5	1.9	1.4	0.8	0.7	0.6	0.5
5	0.2	0.0	-0.2	-0.4	-0.3	-0.1	0.0	0.5	1.1	1.1	1.1	1.1	2.0	2.7	2.0	1.5	1.0	0.9	0.7	0.6	0.5
4	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	0.0	0.4	0.8	1.0	1.1	1.3	1.5	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.5
3	0.2	0.1	-0.1	-0.1	0.0	-0.1	0.0	0.2	0.5	0.6	0.7	0.9	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4
2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.7	0.8	0.7	0.7	0.6	0.6	0.5	0.5	0.4
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-6(c) Vertical Wind Speed, W_z

Case 6(F) Series No. 1933,

$\overline{W}_x = 11.0\ m\ s^{-1}$, Length of Field L = 7272.8 m, Horizontal Increment Δx = 181.82 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	3.7	3.5	3.3	3.1	2.8	2.6	2.4	2.2	2.0	1.6	1.2	0.8	0.4	0.0	0.0	0.0	0.0	0.8	1.6	2.4	3.2
10	3.7	3.5	3.3	3.1	2.9	2.8	2.6	2.4	2.2	2.0	2.0	2.0	1.5	1.0	0.5	0.0	0.7	1.3	2.0	2.8	3.5
9	3.8	3.6	3.4	3.3	3.1	2.9	2.7	2.5	2.4	2.2	2.0	2.0	2.0	1.5	0.9	0.4	1.1	1.8	2.6	3.3	4.0
8	4.0	4.0	4.0	4.0	4.0	4.0	3.7	3.5	3.3	3.0	2.8	2.5	2.3	2.0	2.0	2.0	2.0	2.0	3.0	4.0	4.7
7	4.1	4.1	4.1	4.0	4.0	4.0	4.0	3.9	4.0	4.0	4.0	4.0	4.0	3.5	3.1	2.8	2.6	3.3	4.0	4.7	5.3
6	4.1	4.1	4.1	4.1	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.0	3.9	3.8	3.9	4.0	2.8	3.5	4.2	4.8	5.4
5	4.2	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.0	4.0	4.0	4.0	3.1	4.0	4.7	5.3	6.0
4	4.2	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.0	4.0	4.0	4.0	3.6	3.2	4.0	4.5	5.0	5.5
3	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4.1	4.1	4.1	4.0	4.0	4.0	4.0	3.1	2.2	2.8	3.5	4.1	4.7	5.3
2	4.4	4.3	4.2	4.1	4.0	4.0	4.0	4.0	4.1	3.4	2.7	2.0	1.7	1.3	1.0	0.7	1.0	1.4	1.7	2.0	3.0
1	4.5	4.3	4.2	4.0	4.0	4.0	4.0	4.0	4.1	4.0	2.0	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	3.2	4.0	4.2	4.4	4.3	4.1	4.0	4.8	5.7	3.8	1.9	0.0	0.3	0.6	0.9	1.3	1.6	1.9	2.0	2.1	2.2
10	3.5	4.3	5.0	4.8	4.7	4.5	4.3	5.2	6.0	4.0	1.9	-0.1	0.2	0.5	0.8	1.2	1.5	1.8	2.1	2.2	2.2
9	4.0	4.9	5.8	5.4	5.0	4.6	4.2	5.1	6.0	3.9	1.8	-0.3	0.0	0.3	0.7	1.0	1.3	1.7	2.0	2.1	2.2
8	4.7	5.3	6.0	5.6	5.2	4.8	4.4	5.1	5.8	3.7	1.6	-0.5	-0.2	0.2	0.5	0.7	1.0	1.3	1.6	1.8	2.1
7	5.3	6.0	5.9	5.8	5.3	4.7	4.2	4.5	4.8	3.0	1.2	-0.7	-0.3	0.0	0.3	0.6	0.9	1.2	1.5	1.8	2.1
6	5.4	6.0	5.8	5.7	5.1	4.6	4.0	3.7	3.5	3.2	1.1	-1.0	-0.5	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8
5	6.0	6.0	6.0	5.3	4.7	4.0	3.5	3.0	2.5	2.0	0.0	-1.7	-1.1	-0.5	0.1	0.2	0.4	0.6	0.7	0.9	1.0
4	5.5	6.0	5.4	4.7	4.1	3.0	1.9	1.6	1.4	1.1	-0.2	-2.0	-1.5	-0.9	-0.4	0.1	0.2	0.2	0.3	0.3	0.4
3	5.3	4.7	4.2	3.6	3.0	1.5	-0.1	0.3	0.7	-0.3	-1.4	-2.1	-1.9	-1.6	-1.0	-0.5	0.1	0.1	0.1	0.1	0.1
2	3.0	4.0	2.7	1.3	0.0	-1.8	-3.5	-1.7	0.1	0.0	-1.1	-2.2	-1.9	-1.6	-1.3	-1.0	-0.5	0.0	0.0	0.0	0.0
1	2.0	3.0	2.0	0.5	-1.0	-2.6	-4.1	-2.0	0.0	0.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.5	-0.9	-0.4	0.1	0.1	0.0

Table 2A-7(a) Wind Speed in Direction of Frontal Motion, W_x

Case 7(G) Series No. 1942,

$\overline{W}_x = 11.8\ m\ s^{-1}$, Length of Field L = 7843.2 m , Horizontal Increment Δx = 196.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	18.3	18.2	18.1	17.9	17.8	18.8	19.8	20.5	21.1	21.8	22.2	22.6	23.1	23.5	23.9	24.3	23.4	22.5	21.6	20.7	19.8
10	18.3	17.9	17.6	17.2	17.9	18.5	19.1	19.8	20.8	21.8	22.1	22.5	22.8	23.1	23.5	23.8	23.2	22.6	22.0	21.4	20.8
9	18.0	17.9	17.8	17.8	17.8	17.8	18.5	19.1	19.8	20.8	21.8	22.0	22.2	22.4	22.6	22.8	22.6	22.4	22.2	22.0	21.8
8	17.8	17.8	17.7	17.7	17.6	17.6	18.3	19.1	19.8	20.3	20.9	21.4	22.0	22.5	22.3	22.0	21.8	22.3	22.8	22.3	21.8
7	16.9	17.1	17.2	17.4	17.5	17.6	17.8	18.8	19.8	20.2	20.7	21.1	21.6	22.0	21.7	21.3	21.0	21.5	21.9	21.9	21.8
6	16.3	16.6	16.8	17.1	17.3	17.6	17.8	18.5	19.1	19.8	20.3	20.8	21.3	21.8	21.6	21.3	21.1	20.8	20.6	20.3	20.1
5	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.2	18.6	19.0	19.4	19.8	20.5	21.1	20.7	20.2	19.8	19.8	19.9	19.9	19.9
4	15.8	16.1	16.5	16.8	17.1	17.5	17.8	18.2	18.6	19.0	19.4	19.8	20.3	20.8	19.8	18.8	17.8	16.8	15.8	15.8	15.8
3	14.8	15.1	15.5	15.8	16.1	16.3	16.6	16.9	17.2	17.4	17.7	18.7	19.8	20.4	19.8	18.6	17.4	16.2	15.0	13.8	13.9
2	13.8	14.1	14.5	14.6	15.1	15.5	15.8	16.2	16.6	17.0	17.4	17.8	19.1	20.3	18.1	16.0	13.8	13.1	12.3	11.6	10.8
1	12.8	13.1	13.5	13.8	14.1	14.4	14.7	14.9	15.2	15.5	15.8	17.8	18.8	19.8	19.8	15.8	12.8	10.8	8.8	8.8	8.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	19.8	17.8	15.8	14.9	13.9	10.9	7.9	4.8	1.8	0.4	-0.9	-2.3	-3.7	-5.0	-6.4	-6.9	-7.5	-8.1	-8.6	-9.2	-9.7
10	20.8	19.2	17.5	15.9	14.4	12.8	9.8	6.8	3.8	0.8	-0.4	-1.6	-2.8	-3.9	-5.1	-6.3	-6.9	-7.5	-8.2	-8.8	-9.4
9	21.8	20.1	18.5	16.8	14.8	12.8	9.8	6.8	3.8	2.5	1.1	-0.2	-1.4	-2.6	-3.8	-5.0	-6.2	-6.7	-7.2	-7.7	-8.2
8	21.8	18.8	15.8	16.3	15.1	14.0	12.8	9.8	6.8	3.8	2.3	0.8	-0.7	-2.2	-2.8	-3.4	-4.0	-4.6	-5.2	-5.8	-6.4
7	21.8	18.8	15.8	16.1	16.5	15.7	14.9	10.9	6.8	5.3	3.8	2.3	0.8	-0.7	-2.2	-2.7	-3.3	-3.8	-4.3	-4.9	-5.4
6	20.1	19.8	18.8	17.8	15.8	15.5	14.1	12.8	10.6	8.4	6.2	4.0	1.8	1.1	0.3	-0.4	-1.2	-1.9	-2.7	-3.4	-4.2
5	19.9	19.0	18.1	17.2	16.3	17.7	15.4	13.1	10.8	9.6	8.5	7.3	6.1	5.0	3.8	2.6	1.5	0.3	-0.9	-2.0	-3.2
4	15.8	15.8	15.8	16.5	17.2	17.9	15.9	13.8	11.8	10.1	8.5	6.8	5.1	3.5	1.8	1.1	0.5	-0.2	-0.9	-1.5	-2.2
3	13.9	14.0	14.0	14.1	16.0	17.8	16.3	14.8	13.3	11.8	10.3	8.8	7.3	5.8	4.3	2.8	1.3	-0.2	-0.5	-0.9	-1.2
2	10.8	11.5	12.1	12.8	15.2	17.6	15.9	14.2	42.5	10.8	9.6	8.3	7.1	5.8	4.6	3.3	2.1	0.8	0.4	0.1	-0.3
1	8.7	8.7	9.8	13.8	15.8	15.8	15.8	13.8	11.8	10.8	9.8	8.8	7.8	6.8	5.8	4.8	3.8	2.8	1.8	1.3	0.8

Table 2A-7(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 7(G) Series No. 1942,

$\overline{W}_x = 11.8\ m\ s^{-1}$, Length of Field L = 7843.2 m, Horizontal Increment Δx = 196.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	1.0	0.5	0.0	-1.0	-1.0	-0.5	0.0	-0.2	-0.5	-0.7	-1.0	-1.1	-1.2	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-2.0	-2.0
10	1.0	0.5	0.0	-1.0	-1.0	-0.5	0.0	-0.5	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.5	-2.0
9	1.0	0.5	0.0	-0.5	-1.0	0.0	0.0	0.0	-1.0	-1.0	-1.1	-1.1	-1.2	-1.3	-1.5	-1.6	-1.7	-1.8	-2.0	-2.1	-2.2
8	1.0	0.5	0.0	-0.9	-0.4	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-0.9	-1.0	-1.1	-1.3	-1.4	-1.5	-1.7	-1.8	-2.0	-2.1
7	1.0	0.5	0.0	-0.8	-0.4	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-0.9	-1.0	-1.3	-1.7	-2.0	-1.5	-0.9	-1.3	-1.7	-2.1
6	1.0	0.4	-0.2	-0.6	-0.3	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-1.0	-1.4	-1.7	-2.0	-1.6	-1.2	-0.8	-1.2	-1.7	-2.1
5	1.0	0.0	-0.2	-0.5	0.0	0.0	0.1	0.1	0.1	-0.2	-0.5	-0.7	-1.0	-1.2	-1.5	-1.4	-1.2	-1.1	-1.0	-1.5	-2.0
4	0.5	0.0	-0.2	-0.4	0.0	0.0	0.0	0.0	0.0	-0.2	-0.3	-0.6	-1.0	-2.0	-2.0	-2.1	-1.5	-0.9	-1.1	-1.3	-1.5
3	0.0	-0.1	-0.2	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.5	-0.7	-1.0	-1.3	-1.6	-1.9	-1.4	-0.9	-0.9	-1.0	-1.0
2	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	0.0	-0.2	-0.3	-0.5	-0.7	-0.8	-1.0	-1.0	-1.0	-1.0	-1.0	-0.6	-0.1	0.3	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-2.0	-1.6	-1.2	-0.8	-0.4	0.0	4.0	4.1	4.1	3.6	3.0	2.5	2.0	1.5	1.0	0.9	0.8	0.7	0.7	0.6	0.5
10	-2.0	-1.8	-1.5	-1.2	-1.0	0.0	1.8	3.5	3.1	2.7	2.3	2.0	1.6	1.2	0.8	0.7	0.7	0.6	0.6	0.6	0.5
9	-2.2	-1.8	-1.3	-0.9	-0.4	0.0	1.5	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5
8	-2.1	-1.9	-1.7	-1.4	-1.2	-1.0	0.0	1.0	2.0	1.8	1.5	1.2	1.0	0.9	0.9	0.8	0.7	0.7	0.6	0.6	0.5
7	-2.1	-2.0	-2.0	-1.9	-1.9	-1.8	-0.9	0.0	0.2	0.4	0.7	0.9	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3
6	-2.1	-1.7	-1.3	-0.9	-1.5	-2.0	-1.0	0.0	0.3	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1
5	-2.0	-1.6	-1.2	-0.8	-1.2	-1.6	-2.0	-1.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
4	-1.5	-1.1	-0.8	-1.2	-1.6	-2.0	-1.3	-0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.2	0.2
3	-1.0	-0.9	-0.8	-1.1	-1.4	-1.7	-2.0	-1.7	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	0.1	0.2	0.2	0.1	0.1	0.0	0.0
2	0.1	-0.1	-0.3	-0.6	-0.8	-1.0	-0.9	-0.8	-0.7	-0.6	-0.4	-0.3	-0.2	-0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-7(c) Vertical Wind Speed, W_z

Case 7(G) Series No. 1942,

$\overline{W}_x = 11.8 \text{ m s}^{-1}$, Length of Field L = 7843.2 m, Horizontal Increment Δx=196.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.8	1.9	3.0	4.1	3.4	2.7	2.0	2.0	2.0	2.0	1.0	0.0	-1.5	-0.7	0.0	0.0	0.0	-2.0	-2.5	-3.0	-3.6
10	0.8	2.0	3.0	4.0	3.1	2.2	1.1	0.0	0.0	0.0	0.0	-1.0	-2.0	-1.3	-0.7	0.0	-1.0	-2.1	-2.7	-3.4	-4.0
9	1.0	2.1	2.6	3.1	2.6	2.1	0.7	-0.6	-2.0	-1.4	-0.8	-1.4	-2.0	-1.6	-1.2	-0.8	-1.9	-2.5	-3.0	-3.5	-4.1
8	1.0	2.1	2.1	2.0	2.0	2.0	0.0	-2.0	-2.1	-1.9	-1.7	-1.9	-2.1	-2.0	-1.9	-1.8	-2.0	-4.0	-4.0	-4.0	-4.2
7	0.2	2.0	2.0	2.0	2.0	2.0	0.0	-2.0	-1.9	-1.9	-1.8	-2.0	-2.1	-2.0	-1.9	-2.1	-2.3	-4.0	-4.2	-4.4	-4.6
6	0.0	0.3	0.7	0.5	0.2	0.0	-1.0	-2.0	-2.0	-1.9	-1.9	-2.0	-2.1	-2.1	-2.0	-2.0	-3.0	-4.1	-4.4	-4.6	-4.9
5	0.0	0.0	0.0	0.0	0.0	-1.0	-2.0	-2.0	-2.1	-2.0	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-4.0	-4.1	-4.1	-4.2	-4.2
4	-0.2	-0.6	-0.9	-1.3	-1.6	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-2.3	-2.3	-2.8	-3.3	-3.8	-4.1	-4.1	-4.1	-4.0	-4.0
3	-0.3	-0.7	-1.1	-1.6	-2.0	-2.1	-2.2	-2.2	-2.1	-2.0	-2.0	-2.5	-3.0	-3.5	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.5
2	-0.5	-0.9	-1.2	-1.6	-2.0	-1.8	-1.5	-1.3	-1.0	-0.8	-1.2	-1.7	-2.1	-3.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.4	-2.8
1	-0.5	-0.7	-0.9	-1.1	-1.3	-1.5	-1.7	0.0	0.0	0.0	0.0	-1.0	-2.0	-3.0	-4.1	-4.1	-4.0	-4.0	-3.6	-3.2	-2.8

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-3.6	-4.1	-4.1	-4.0	-4.0	-2.0	0.0	2.0	2.4	2.8	3.3	3.7	4.1	5.1	6.0	6.1	6.1	6.2	6.1	6.1	6.0
10	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-1.9	0.1	2.2	2.6	2.9	3.3	3.6	4.0	4.7	5.3	6.0	6.0	6.0	6.0	5.6
9	-4.1	-4.2	-4.2	-4.3	-4.3	-4.1	-2.0	0.0	2.0	2.5	2.9	3.3	3.8	4.1	4.5	4.8	5.2	5.5	5.3	5.2	5.0
8	-4.2	-4.3	-4.5	-4.6	-4.8	-3.3	-1.9	-0.4	1.1	1.5	1.8	2.5	3.3	4.0	4.2	4.4	4.7	4.9	4.8	4.7	4.6
7	-4.6	-4.8	-5.0	-5.2	-5.4	-4.7	-3.9	-1.5	0.8	1.2	1.6	2.0	2.7	3.3	4.0	4.1	4.2	4.2	4.1	4.1	4.0
6	-4.9	-5.2	-5.5	-5.7	-6.0	-5.0	-4.0	-1.9	0.2	0.7	1.1	1.6	2.1	2.7	3.4	4.0	4.0	4.0	4.0	4.0	3.6
5	-4.2	-4.3	-4.3	-5.2	-6.0	-5.0	-4.0	-2.0	0.1	0.6	1.0	1.5	1.9	2.4	3.0	3.5	3.4	3.3	3.3	3.2	3.1
4	-4.0	-4.5	-4.9	-5.4	-5.9	-4.6	-3.3	-2.0	0.0	0.4	0.8	1.2	1.6	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.6
3	-3.5	-3.8	-4.1	-4.1	-4.0	-3.0	-2.0	-0.9	0.2	0.5	0.8	1.1	1.4	1.7	2.0	2.0	2.1	2.2	2.2	2.3	2.3
2	-2.8	-3.2	-3.5	-3.9	-2.0	-1.0	0.0	0.6	1.2	1.3	1.4	1.5	1.7	1.8	1.9	2.0	2.0	2.0	2.0	2.2	2.3
1	-2.8	-2.4	-2.0	0.0	0.7	1.4	2.1	2.1	2.0	2.0	1.5	1.0	1.1	1.3	1.4	1.6	1.7	1.9	2.0	2.1	2.2

Table 2A-8(a) Wind Speed in Direction of Frontal Motion, W_x

Case 8(H) Series No. 1712,

$\overline{W}_x = 8.5 \text{ m s}^{-1}$, Length of Field L = 5555.6 m, Horizontal Increment Δx = 138.89 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	6.3	6.7	7.2	7.6	8.1	8.5	9.5	7.8	6.0	4.3	5.3	6.4	7.5	8.5	9.6	10.6	10.6	10.6	10.6	10.1	9.6
10	6.4	6.8	7.2	7.7	8.1	8.5	10.2	8.4	6.7	7.2	7.6	8.1	8.5	9.4	10.4	10.4	10.5	10.6	10.6	10.0	9.4
9	6.4	6.9	7.5	9.0	8.5	9.5	10.5	9.1	7.7	6.3	7.4	8.5	10.5	10.8	11.0	11.3	11.5	11.1	10.7	10.3	9.8
8	6.4	6.9	7.5	8.0	8.5	9.6	10.6	9.4	8.3	6.5	8.6	9.9	11.2	12.5	12.2	12.3	12.3	12.4	11.8	11.1	10.5
7	6.7	7.2	7.7	8.2	8.7	9.6	10.5	9.2	8.0	6.7	8.7	10.6	12.6	12.6	12.6	12.7	12.7	12.7	12.1	11.6	11.0
6	7.5	7.8	8.0	8.3	8.5	9.0	9.5	8.7	7.8	7.0	8.5	9.3	10.1	11.0	11.8	12.6	12.3	11.9	11.6	11.2	10.9
5	6.8	7.2	7.7	8.1	8.5	8.3	8.0	7.8	7.5	8.0	8.5	9.4	10.2	11.1	11.9	12.8	12.5	12.3	12.0	11.7	11.4
4	6.5	6.5	6.5	6.4	6.4	6.4	6.4	6.3	6.3	6.3	8.5	9.3	10.2	11.0	11.9	12.7	12.5	12.2	12.0	11.7	11.5
3	6.3	6.4	6.4	6.5	5.8	5.2	4.5	5.2	5.8	6.5	8.0	9.5	10.5	11.5	12.5	12.7	12.2	11.6	11.1	10.5	10.5
2	6.0	5.9	5.8	5.6	5.5	4.1	2.7	3.7	4.8	6.0	7.3	8.5	9.6	10.6	11.7	12.7	12.2	11.6	11.1	10.5	10.5
1	5.5	5.3	5.0	4.8	4.5	3.3	2.0	3.3	4.5	5.5	6.5	7.5	8.5	10.5	12.5	12.5	11.6	10.6	10.6	10.6	10.6

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	9.6	9.0	8.5	6.0	3.4	0.9	-1.6	-2.0	-2.4	-2.7	-3.1	-3.5	-3.6	-3.6	-3.7	-4.1	-4.6	-5.1	-5.5	-5.6	-5.7
10	9.4	8.7	8.1	7.5	5.2	2.8	0.5	-0.5	-1.5	-1.8	-2.1	-2.5	-2.8	-3.2	-3.5	-3.9	-4.3	-4.6	-5.0	-5.3	-5.7
9	9.8	9.4	9.0	8.6	6.6	4.6	2.6	1.2	-0.2	-1.6	-1.9	-2.1	-2.4	-2.7	-3.0	-3.2	-3.5	-4.0	-4.5	-5.0	-5.5
8	10.5	10.0	9.4	8.9	8.4	6.0	3.5	3.0	2.6	2.1	1.7	-1.6	-1.6	-1.6	-1.7	-1.7	-1.7	-2.4	-3.2	-3.9	-4.7
7	11.0	10.4	9.9	9.4	9.0	8.5	6.7	4.9	3.1	1.3	-0.5	-0.7	-0.9	-1.1	-1.2	-1.4	-1.6	-2.3	-3.1	-3.8	-4.5
6	10.9	10.5	10.4	10.4	9.4	8.5	6.9	5.2	3.6	1.9	0.3	0.0	-0.2	-0.5	-0.7	-1.0	-1.2	-1.5	-2.3	-3.2	-4.0
5	11.4	11.2	10.9	10.6	9.6	8.7	6.7	4.6	2.6	2.1	1.6	1.0	0.5	0.0	-0.5	-1.0	-1.5	-2.0	-2.5	-3.0	-3.5
4	11.5	11.2	11.0	10.7	10.5	8.8	7.1	5.4	4.9	4.3	3.8	3.3	2.7	2.2	1.7	1.1	0.6	-0.2	-0.9	-1.7	-2.5
3	10.5	10.6	10.6	10.6	9.9	9.2	8.5	7.5	6.5	5.5	4.5	3.5	2.5	2.0	1.5	1.0	0.5	0.0	-0.5	-1.0	-1.5
2	10.5	10.5	10.6	10.6	10.6	9.6	8.5	7.8	7.1	6.3	5.6	4.9	4.1	3.4	2.7	1.9	1.2	0.5	-0.1	-0.6	-1.2
1	10.6	10.6	10.6	10.6	10.1	9.6	9.1	8.6	7.9	7.1	6.4	5.7	4.9	4.2	3.4	2.7	2.0	1.2	0.5	0.0	-0.5

Table 2A-8(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 8(H) Series No. 1712,

$\overline{W}_x$ =8.5 m s^{-1}, Length of Field L = 5555.6 m, Horizontal Increment Δx = 196.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	3.0	1.0	-1.0	-2.1	-1.0	0.1	1.2	-1.0	-1.5	-2.0	-0.9	0.1	0.5	0.9	1.4	1.8	2.2	1.8	1.3	0.9	0.4
10	3.5	1.2	-1.0	-2.1	-1.0	0.1	1.2	0.1	-1.0	-2.1	-1.4	-0.7	0.0	0.4	0.9	1.3	1.7	1.3	0.9	0.4	0.0
9	4.0	1.5	-1.0	-2.1	-1.0	0.0	1.1	0.0	-1.1	-2.2	-1.4	-0.6	-0.3	0.0	0.5	1.0	1.1	0.7	0.4	0.0	0.0
8	4.1	1.5	-1.0	-2.0	-1.0	0.0	1.0	-0.3	-1.7	-3.0	-1.9	-0.7	-0.4	-0.1	0.3	0.6	0.9	0.6	0.3	0.0	-0.1
7	3.8	1.4	-1.0	-1.7	-0.9	-0.2	0.6	-0.6	-1.9	-3.1	-2.0	-0.8	-1.0	-0.5	0.0	0.2	0.5	0.2	0.0	0.0	-0.1
6	3.0	1.0	-1.0	-1.5	-0.8	-0.2	0.5	-1.0	-2.5	-3.0	-1.9	-0.8	-1.1	-0.7	-0.3	0.1	0.1	0.0	0.0	0.0	-0.1
5	2.0	0.5	-1.0	-1.0	-1.1	-0.3	0.4	-0.8	-2.0	-1.6	-1.2	-0.8	-1.1	-0.7	-0.4	0.0	0.0	-0.1	-0.1	-0.2	-0.2
4	1.5	0.1	-1.0	-1.1	-1.0	0.3	-0.3	-1.0	-1.2	-1.5	-1.0	-1.0	-1.0	-0.8	-0.5	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2
3	1.0	0.0	-1.0	-0.9	-0.9	0.2	-0.2	-0.6	-1.0	-1.0	-1.0	-0.9	-0.7	-0.6	-0.6	-0.5	-0.5	-0.4	-0.4	-0.3	-0.2
2	0.2	0.0	-0.1	-0.2	-0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.4	0.0	1.7	3.3	5.0	5.2	4.4	3.6	2.8	2.0	1.9	1.7	1.6	1.4	1.3	1.1	1.0	0.8	0.6	0.5	0.3
10	0.0	0.1	0.2	1.6	3.1	4.5	3.9	3.3	2.6	2.0	1.5	1.0	1.0	1.1	1.1	1.0	0.8	0.7	0.6	0.4	0.3
9	0.0	0.1	0.1	1.0	2.0	3.0	4.1	3.5	3.0	2.3	1.6	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2
8	-0.1	-0.1	0.0	0.0	1.0	2.1	3.1	3.0	3.0	2.0	1.1	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.3	0.2
7	-0.1	-0.1	-0.1	0.0	0.0	1.0	2.0	3.0	2.3	1.6	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.3	0.2
6	-0.1	-0.1	0.2	0.4	0.7	1.0	1.8	2.5	2.2	1.8	1.5	1.2	0.8	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2
5	-0.2	-0.2	-0.1	-0.1	0.0	0.0	1.0	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.4	0.3	0.2	0.1	0.4	0.6	0.9
4	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.7	1.5	1.4	1.2	1.0	0.9	0.7	0.6	0.4	0.3	0.2	0.0	0.0	0.0	0.0
3	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.1	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.0	0.1	0.1
2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-8(c) Vertical Wind Speed, W_z

Case 8(H) Series No. 1712,

$\overline{W}_x = 8.5 \text{ m s}^{-1}$, Length of Field L = 5555.6 m, Horizontal Increment Δx = 138.89 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	2.3	2.6	3.0	3.3	3.7	4.0	4.7	5.3	6.0	6.0	6.0	6.0	4.0	3.3	2.7	2.0	1.7	1.4	1.0	0.7	0.4
10	2.3	2.6	2.9	3.2	3.4	3.7	4.0	4.2	4.4	4.6	4.8	4.0	3.0	2.0	1.5	1.0	0.9	0.9	0.8	0.5	0.3
9	2.2	2.4	2.7	2.9	3.1	3.3	3.5	3.8	4.0	3.3	2.7	2.0	1.5	1.0	0.5	0.0	0.2	0.3	0.5	0.2	0.0
8	2.2	2.1	2.0	2.2	2.3	2.5	2.6	2.8	2.5	2.2	1.9	0.9	0.0	-0.1	-0.1	-0.2	0.0	0.1	0.3	0.0	0.0
7	2.0	2.0	2.0	2.0	2.1	2.1	2.0	2.0	2.0	1.0	0.0	-0.5	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.3	0.0	0.0
6	1.0	1.2	1.5	1.8	2.0	1.6	1.2	0.8	0.4	0.0	-1.0	-2.0	-1.7	-1.4	-1.0	-0.7	-0.4	-0.1	0.5	0.2	0.0
5	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	-0.7	-1.3	-2.0	-2.0	-2.0	-2.0	-1.5	-1.0	-0.5	0.0	0.7	0.6	0.5
4	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	-0.5	-1.0	-1.5	-2.0	-2.1	-2.2	-2.1	-2.0	-1.5	-1.0	-0.5	0.0	0.3	0.5	0.8
3	-1.5	-1.6	-1.7	-1.8	-1.8	-1.9	-2.0	-2.1	-2.2	-2.3	-2.4	-2.5	-2.3	-2.0	-1.5	-0.9	-0.3	0.2	0.7	1.3	1.3
2	-2.0	-2.3	-2.6	-2.9	-3.1	-3.4	-3.7	-4.0	-3.7	-3.4	-3.0	-2.7	-2.4	-2.1	-1.4	-0.7	0.0	0.4	0.8	1.2	1.6
1	-2.5	-2.9	-3.3	-3.6	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.5	-3.0	-2.4	-1.9	0.0	0.5	1.0	1.5	2.0	2.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.4	0.1	0.0	0.7	1.5	2.3	3.0	3.3	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.2
10	0.3	0.0	0.0	0.0	0.0	0.9	1.8	2.1	2.4	2.7	3.1	3.4	3.7	4.0	4.0	4.0	4.0	4.1	4.1	4.2	4.2
9	0.0	0.0	0.0	0.0	0.0	0.9	1.9	2.3	2.7	3.0	3.4	3.8	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2
8	0.0	-0.1	-0.1	-0.1	0.0	0.9	1.9	2.2	2.5	2.9	3.2	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.0	4.1	4.1
7	0.0	0.0	0.0	0.0	0.0	0.9	1.9	2.2	2.4	2.7	2.9	3.2	3.3	3.5	3.6	3.7	3.8	4.0	4.1	4.1	4.1
6	0.0	0.0	0.0	0.0	0.0	0.0	1.9	2.1	2.3	2.6	2.8	3.0	3.1	3.3	3.4	3.6	3.7	3.9	4.0	4.1	4.1
5	0.5	0.3	0.2	0.1	0.0	1.0	2.0	2.2	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.4	3.6	3.7	3.8	3.9	4.0
4	0.8	0.8	0.7	0.7	0.7	1.4	2.1	2.4	2.7	3.1	3.4	3.7	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.8	3.8
3	1.3	1.3	1.4	1.4	1.4	1.8	2.1	2.5	2.9	3.2	3.6	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.5
2	1.6	1.5	1.5	1.6	1.8	1.9	2.3	2.6	3.0	3.4	3.7	4.1	4.0	3.9	3.8	3.7	3.7	3.6	3.5	3.4	3.3
1	2.0	2.0	2.0	2.0	2.0	2.0	2.4	2.8	3.3	3.7	4.1	4.1	4.0	3.9	3.8	3.7	3.5	3.4	3.3	3.2	3.1

Table 2A-9(a) Wind Speed in Direction of Frontal Motion, W_x

Case 9(I) Series No. 1507,

$\overline{W}_x$ = 11.5 m s^{-1}, Length of Field L = 7407.6 m, Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	13.8	14.0	14.2	14.4	14.6	14.7	14.9	15.1	15.3	15.5	16.5	17.5	17.8	18.0	18.3	18.5	18.7	19.0	19.3	19.5	19.6
10	13.7	13.9	14.1	14.2	14.4	14.6	14.8	15.0	15.1	15.3	15.5	15.8	16.2	16.5	16.8	17.2	17.5	17.7	18.0	18.2	18.5
9	13.7	13.5	13.7	13.9	14.1	14.3	14.5	14.7	14.9	15.1	15.3	15.5	15.8	16.0	16.3	16.5	16.8	17.0	17.3	17.5	17.6
8	13.6	13.1	13.3	13.6	13.8	13.8	13.8	13.7	13.7	13.7	13.7	13.6	13.6	13.6	14.7	15.8	16.0	16.2	16.4	16.5	16.7
7	13.5	13.1	12.6	12.8	13.1	13.3	13.5	13.5	13.5	13.6	13.6	13.6	13.6	13.5	14.4	15.4	15.5	15.6	15.6	15.7	15.4
6	12.5	12.5	12.5	12.5	12.5	12.5	12.6	12.6	12.6	12.6	12.6	12.6	12.6	13.1	13.5	13.8	14.0	14.3	14.6	14.9	15.1
5	12.5	12.4	12.3	12.1	12.0	11.9	11.8	11.6	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.8	14.0	14.1	14.3	14.5
4	11.8	11.5	11.6	11.6	11.7	11.6	11.4	10.9	10.3	10.7	11.1	11.5	11.7	12.3	12.9	13.5	13.6	13.7	13.7	13.8	13.9
3	11.7	11.5	11.3	11.4	11.4	10.7	9.9	9.2	9.5	9.9	10.2	10.5	10.8	11.2	11.5	12.5	13.5	13.4	13.2	13.4	13.7
2	11.6	11.2	10.8	10.4	10.1	9.7	9.3	7.5	8.0	8.4	8.9	9.4	9.9	10.4	11.0	11.5	11.9	12.3	12.8	13.2	13.6
1	11.5	11.1	10.7	10.3	9.9	9.5	7.5	7.4	7.4	8.0	8.5	9.0	9.5	10.1	10.8	11.4	11.8	11.6	11.5	12.5	13.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	19.6	19.7	19.5	18.1	16.8	15.4	13.5	12.5	11.5	10.5	9.5	5.5	1.5	-0.6	-0.9	-1.1	-1.4	-1.7	-2.0	-2.2	-2.5
10	18.5	18.7	17.6	16.6	15.5	14.3	13.0	12.4	11.8	11.1	10.5	6.2	1.8	-0.5	-1.0	-1.5	-2.0	-2.5	-2.5	-2.6	-2.6
9	17.6	17.6	17.5	16.2	14.8	13.5	13.1	12.7	12.3	11.9	11.5	7.5	3.5	-0.5	-1.1	-1.8	-2.4	-2.4	-2.4	-2.5	-2.5
8	16.7	16.9	16.1	15.4	14.3	13.2	12.9	12.5	12.2	11.8	11.5	7.0	2.5	0.5	-1.5	-2.0	-2.5	-2.5	-2.5	-2.5	-2.5
7	15.4	15.1	14.8	14.5	13.4	13.1	12.8	12.4	12.1	11.8	11.5	7.3	3.0	0.7	-1.5	-2.0	-2.5	-2.5	-2.5	-2.5	-2.5
6	15.1	15.4	14.4	13.5	12.6	11.7	11.7	11.8	11.8	11.8	9.0	6.2	3.4	1.1	-1.3	-1.9	-2.6	-2.6	-2.6	-2.6	-2.6
5	14.5	13.9	13.3	12.6	12.0	11.4	11.5	11.6	11.7	11.8	9.1	6.3	3.6	1.1	-1.3	-1.9	-2.6	-2.6	-2.6	-2.6	-2.6
4	13.9	13.3	12.7	12.1	11.5	11.2	11.4	11.5	11.6	11.8	9.4	6.9	4.5	1.6	-1.2	-2.5	-2.5	-2.5	-2.6	-2.6	-2.6
3	13.7	13.0	12.2	11.5	11.3	11.0	11.2	11.3	11.5	11.7	11.6	8.4	5.3	2.7	0.1	-2.5	-2.5	-2.5	-2.6	-2.6	-2.6
2	13.6	12.5	11.4	11.2	11.0	10.8	11.0	11.2	11.4	11.6	11.6	8.6	5.5	2.9	0.2	-2.4	-2.4	-2.5	-2.5	-2.6	-2.6
1	13.5	12.9	12.3	11.7	11.1	10.5	10.8	11.1	11.3	11.6	11.5	8.6	5.7	1.8	-2.2	-2.5	-2.5	-2.6	-2.6	-2.7	-2.7

Table 2A-9(b) Wind Speed Perpendicular to Frontal Motion , W_y

Case 9(I) Series No. 1507,

$\bar{W}_x = 11.5$ m s^{-1}, Length of Field L = 7407.6 m, Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.0	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.1	0.9	0.8	0.7	1.0	1.5	2.0	2.5	3.0	3.3	3.7	4.0
10	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.0	0.9	0.7	1.1	1.6	2.0	2.6	3.2	3.5	3.7	4.0
9	0.3	0.2	0.2	0.1	0.0	0.2	0.5	0.7	1.0	1.2	1.1	1.0	0.9	0.7	1.0	1.6	2.3	2.9	3.5	4.0	4.4
8	0.3	0.2	0.1	0.0	-0.1	0.1	0.3	0.6	0.8	1.0	1.1	0.9	0.8	0.6	1.1	1.5	2.0	2.5	2.9	3.4	3.8
7	0.3	0.2	0.1	0.0	-0.1	0.0	0.2	0.4	0.7	0.9	1.1	0.9	0.8	0.6	0.9	1.2	2.0	2.7	3.5	3.8	4.2
6	0.2	0.1	0.0	-0.1	-0.2	0.0	0.2	0.3	0.4	0.6	0.7	0.8	0.6	0.5	0.7	1.0	1.8	2.5	3.3	4.1	3.5
5	0.2	0.1	-0.1	-0.2	0.0	0.2	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.2	0.5	0.7	1.0	2.0	3.0	3.4	3.8
4	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.1	0.2	0.1	0.0	-0.1	-0.1	-0.2	-0.1	0.1	0.5	1.0	1.4	2.2	2.9	2.5
3	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.1	0.2	0.1	0.0	-0.1	-0.2	-0.3	-0.2	0.0	0.0	0.0	0.7	1.5	1.8	2.0
2	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	0.0	0.0	0.1	0.9	0.9	0.8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	4.0	4.3	3.2	2.1	1.0	0.6	0.1	0.0	-0.1	0.0	1.9	3.0	4.2	3.0	1.9	1.6	1.2	0.9	0.7	0.5	0.3
10	4.0	4.3	3.0	2.0	1.0	0.6	0.1	0.0	-0.1	0.4	1.0	2.6	4.2	2.8	1.5	1.0	0.8	0.7	0.5	0.4	0.2
9	4.4	3.6	2.8	1.9	1.1	0.6	0.1	0.0	-0.1	0.3	0.8	2.3	3.9	2.5	1.2	1.0	0.9	0.7	0.5	0.4	0.2
8	3.8	4.3	2.9	1.5	1.0	0.5	0.0	-0.1	-0.1	0.2	0.5	1.8	3.0	2.0	1.0	0.9	0.7	0.6	0.5	0.3	0.2
7	4.2	3.0	1.9	1.4	0.9	0.5	0.0	-0.1	-0.2	-0.1	0.0	1.2	2.4	1.6	0.8	0.7	0.6	0.4	0.3	0.2	0.1
6	3.5	2.8	2.2	1.5	1.0	0.5	0.0	-0.1	-0.2	0.2	0.6	1.0	1.9	1.7	1.5	1.2	1.0	0.8	0.6	0.3	0.1
5	3.8	3.0	2.3	1.5	1.0	0.5	0.0	-0.1	-0.2	0.0	0.3	0.5	0.9	1.3	1.1	1.0	0.8	0.6	0.4	0.3	0.1
4	2.5	2.1	1.8	1.4	1.0	0.5	0.0	-0.2	-0.3	-0.2	-0.1	0.0	0.2	0.5	0.7	1.0	0.8	0.6	0.4	0.2	0.0
3	2.0	1.8	1.5	1.2	1.0	0.5	0.0	-0.1	-0.1	-0.2	0.0	0.3	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.0
2	0.8	0.8	0.8	0.7	0.7	0.5	0.2	0.0	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-9(c) Vertical Wind Speed, W_z

Case 9(I) Series No. 1507,

$\overline{W}_x = 11.5\ m\ s^{-1}$, Length of Field L = 7407.6 m., Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-3.7	-4.0	-4.0	-4.0	-3.9	-3.9	-3.9	-3.9	-4.0	-4.0	-4.0	-4.0	-4.0	-2.0	0.0	0.4	0.8	1.2	1.6	2.0	4.5
10	-3.2	-3.6	-4.0	-3.8	-3.5	-3.3	-3.0	-2.8	-3.1	-3.3	-3.6	-3.9	-2.4	-0.8	0.7	1.0	1.4	1.7	2.0	4.0	6.1
9	-3.0	-3.2	-3.5	-3.7	-3.4	-3.0	-2.7	-2.3	-2.0	-2.0	-2.0	-2.0	-2.0	0.0	0.6	1.2	1.8	2.4	3.0	5.2	7.4
8	-2.7	-2.6	-2.4	-2.3	-2.1	-2.0	-1.8	-1.5	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	0.6	1.2	1.8	3.5	5.3	7.0	8.8
7	-2.5	-2.2	-1.9	-1.6	-1.3	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.7	1.3	2.0	2.0	2.0	2.0	4.0	6.0	8.0	10.0
6	-1.0	-0.9	-0.7	-0.6	-0.4	-0.3	-0.1	0.0	0.5	1.0	1.5	2.0	2.4	2.8	3.2	3.5	3.9	4.3	6.9	9.4	12.0
5	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.8	2.0	2.5	3.0	3.5	4.0	3.7	3.3	3.7	4.0	6.5	9.0	11.5	14.0
4	2.0	2.0	2.0	2.0	2.0	2.4	2.8	3.2	3.6	4.0	5.0	6.0	5.5	5.0	4.5	4.0	6.4	8.8	11.2	13.6	16.0
3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.7	5.3	6.0	7.0	8.0	6.9	5.9	4.8	6.9	9.0	11.1	13.2	15.3	17.4
2	6.0	5.8	5.6	5.3	5.1	5.6	6.0	6.8	7.6	8.3	9.1	9.9	8.3	6.6	5.0	7.1	9.3	11.4	13.6	15.7	17.9
1	6.3	6.2	6.2	6.1	6.0	6.5	7.0	7.5	8.0	9.0	10.0	10.0	10.0	7.8	5.7	7.5	9.3	11.6	14.0	16.9	19.8

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	4.5	6.9	9.4	11.9	12.0	12.0	12.1	12.1	12.0	13.0	12.3	11.7	11.0	10.8	10.6	10.4	10.2	10.0	9.8	9.6	9.3
10	6.1	8.1	10.2	12.2	12.1	12.1	12.0	12.7	13.3	14.0	12.9	11.8	11.5	11.3	11.0	10.8	10.5	10.3	10.0	9.6	9.3
9	7.4	9.6	11.8	12.2	12.5	12.9	13.3	13.6	14.0	14.0	14.0	12.0	11.7	11.4	11.1	10.9	10.6	10.3	10.0	9.7	9.4
8	8.8	10.5	12.3	14.0	14.0	14.0	14.1	14.1	14.1	14.1	13.3	12.5	12.2	11.8	11.5	11.1	10.8	10.4	10.1	9.8	9.5
7	10.0	12.0	13.1	14.3	14.3	14.2	14.2	14.2	14.2	14.1	14.1	13.0	12.0	10.9	10.7	10.6	10.4	10.3	10.1	9.7	9.3
6	12.0	12.9	13.7	14.6	15.4	16.3	15.8	15.3	14.7	14.2	13.2	12.3	11.3	10.3	10.2	10.2	10.1	10.1	10.0	9.5	9.0
5	14.0	14.9	15.9	16.9	17.8	16.5	15.3	14.0	14.0	14.0	14.0	12.7	11.3	10.0	9.9	9.8	9.7	9.6	9.5	9.0	8.5
4	16.0	16.5	17.1	17.6	18.2	16.9	15.6	14.4	13.1	12.3	11.5	10.6	9.8	9.0	8.9	8.8	8.7	8.5	8.4	8.3	8.2
3	17.4	17.9	18.4	18.8	19.3	17.5	15.6	13.8	12.0	12.0	12.0	12.0	10.7	9.3	8.0	8.1	8.2	8.3	8.3	8.2	8.2
2	17.9	20.0	20.0	20.0	20.0	20.0	17.3	14.7	12.0	11.2	10.4	9.6	8.8	8.0	8.0	8.0	8.0	8.1	8.1	8.1	8.1
1	19.8	20.0	20.3	20.2	20.1	20.0	16.0	12.0	12.0	11.9	11.9	11.9	9.9	7.8	7.8	7.9	7.9	7.9	7.9	8.0	8.0

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Table 2A-10(a) Wind Speed in Direction of Frontal Motion, W_x

Case 10(J) Series No. 2206,

$\overline{W}_x = 13.1 \text{ m s}^{-1}$, Length of Field L = 8510.8 m, Horizontal Increment Δx = 212.77 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	21.3	20.4	19.5	19.6	17.7	16.8	16.5	16.2	16.0	15.7	15.4	15.1	16.1	17.1	17.2	17.2	17.1	16.8	16.4	16.1	15.7
10	21.2	20.2	19.2	18.1	17.1	16.8	16.5	16.2	15.9	15.6	15.3	15.0	15.5	16.1	16.6	17.1	16.8	16.6	16.3	16.0	15.7
9	21.1	19.8	18.5	17.2	16.9	16.6	16.3	15.9	15.6	15.3	15.0	15.1	15.1	15.4	15.8	16.1	16.0	15.8	15.7	15.6	15.4
8	19.1	18.4	17.7	17.0	16.5	16.1	15.6	15.1	15.1	15.1	15.1	15.1	15.1	15.1	15.3	15.4	15.6	15.8	16.0	16.1	16.3
7	17.1	18.0	17.3	16.6	16.1	15.6	15.1	14.7	14.3	13.9	14.1	14.4	14.6	14.9	15.1	15.3	15.5	15.7	15.8	16.0	16.2
6	15.9	17.2	16.7	16.2	15.7	15.2	14.5	13.8	13.1	13.4	13.7	14.0	14.2	14.5	14.8	15.1	15.3	15.5	15.7	15.9	16.1
5	15.1	15.6	16.1	15.7	15.4	15.0	14.3	13.5	12.8	12.9	13.0	13.1	13.2	13.6	14.0	14.3	14.7	15.1	15.2	15.4	15.5
4	14.1	14.4	14.8	15.1	14.4	13.8	13.1	12.6	12.1	12.3	12.5	12.7	12.9	13.1	13.5	13.9	14.5	15.1	15.1	15.2	15.2
3	13.1	12.9	12.7	12.5	12.4	12.2	12.0	11.8	11.6	11.9	12.1	12.4	12.7	12.9	13.2	13.8	14.5	15.1	15.1	15.1	15.1
2	11.1	10.4	9.8	9.1	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.9	11.1	12.1	13.1	12.1	11.1	11.1	11.1	11.1
1	9.1	8.1	7.1	7.1	7.8	8.4	9.1	9.4	9.6	9.9	10.1	10.4	10.6	10.9	11.1	12.1	13.1	11.3	10.8	10.2	9.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	15.7	15.4	15.0	14.7	14.3	14.0	13.6	13.3	12.9	8.8	4.6	3.1	2.7	2.3	2.0	1.6	1.2	0.8	0.4	-0.1	-0.5
10	15.7	15.5	15.2	15.7	16.2	16.7	17.2	15.2	13.1	9.1	5.1	3.1	2.6	2.2	1.7	1.2	0.8	0.5	0.1	-0.2	-0.6
9	15.4	15.3	15.7	16.1	16.5	16.9	17.3	15.6	13.9	9.8	5.6	4.5	3.4	2.2	1.1	0.8	0.5	0.2	-0.1	-0.4	-0.7
8	16.3	16.5	16.6	16.8	17.0	17.1	17.3	14.6	11.9	9.3	6.6	3.9	2.6	1.2	0.9	0.6	0.3	0.0	-0.3	-0.6	-0.9
7	16.2	16.4	16.6	16.8	16.9	17.1	17.3	16.2	15.1	11.1	7.1	5.1	3.1	1.1	0.7	0.2	-0.2	-0.7	-0.8	-0.8	-0.9
6	16.1	16.3	16.4	16.6	16.8	17.0	17.2	16.1	15.1	12.0	9.0	5.9	2.8	2.1	1.3	0.6	-0.2	-0.9	-0.9	-1.0	-1.0
5	15.5	15.6	15.8	15.9	16.0	16.2	16.3	15.1	13.8	12.6	9.4	6.3	3.1	2.1	1.2	0.2	-0.8	-0.8	-0.9	-0.9	-1.0
4	15.2	15.3	15.3	15.4	15.4	14.9	14.5	14.0	13.6	13.1	10.2	7.3	4.3	1.4	0.8	0.2	-0.3	-0.9	-0.9	-1.0	-1.0
3	15.1	15.1	15.1	15.1	15.1	14.7	14.3	13.9	13.5	13.1	10.2	7.4	4.5	1.6	1.0	0.4	-0.3	-0.9	-0.9	-1.0	-1.0
2	11.1	11.1	11.1	11.1	11.0	11.0	11.0	11.0	11.0	11.0	8.7	6.4	4.1	1.8	0.9	0.1	-0.8	-0.8	-0.9	-0.9	-1.0
1	9.7	9.1	9.1	9.1	9.1	9.0	9.0	9.0	9.3	9.6	9.1	6.6	4.0	2.3	0.6	-0.2	-1.1	-1.1	-1.1	-1.1	-1.1

Table 2A-10(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 10(J) Series No. 2206,

$\overline{W}_x = 13.1$ m s^{-1}, Length of Field L = 8510.8 m, Horizontal Increment Δx = 212.77 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.4	0.7	1.0	0.9	0.9	0.8	-0.1	0.0	0.1	0.2	0.5	0.8	1.1	0.6	0.0	-0.1	-0.1	0.1	0.2	-0.3	-0.8
10	0.3	0.5	0.8	1.0	0.7	0.3	0.0	-0.1	-0.1	0.2	0.4	0.7	1.0	0.6	0.2	-0.2	-0.6	-0.2	0.2	-0.2	-0.7
9	0.3	0.4	0.4	0.5	0.3	0.1	-0.1	0.0	0.1	0.2	0.4	0.5	0.6	0.0	-0.3	-0.6	-0.9	-0.4	0.1	0.0	-0.6
8	0.3	0.2	0.2	0.2	0.1	0.1	0.0	-0.1	-0.1	0.1	0.3	0.5	0.1	-0.2	-0.6	-1.0	-0.9	-0.8	0.0	-0.3	-0.7
7	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.1	0.0	0.2	0.1	0.0	-0.5	-1.0	-1.0	-1.1	-0.6	-0.2	-0.5	-0.7
6	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.1	0.1	0.2	-0.1	-0.5	-0.8	-0.9	-1.1	-1.2	-0.9	-0.7	-0.4	-0.7
5	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	-0.2	-0.4	-0.7	-0.9	-1.1	-0.9	-0.8	-0.6	-0.5	-0.7
4	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.4	-0.6	-0.9	-1.1	-1.0	-1.0	-0.9	-0.9	-0.7	-0.9
3	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.4	-0.5	-0.7	-0.8	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9	-0.8	-0.9
2	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.4	-0.4	-0.4	-0.3	-0.2	-0.3
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.8	-0.9	-1.0	-1.1	-1.2	-0.8	-0.3	0.1	1.8	3.5	5.2	4.2	3.1	2.1	1.5	1.0	0.9	0.7	0.6	0.4	0.3
10	-0.7	-1.1	-1.1	-1.2	-1.2	-0.8	-0.4	0.0	1.7	3.3	5.0	4.2	3.4	2.6	1.8	1.0	0.8	0.7	0.5	0.4	0.2
9	-0.6	-1.1	-1.1	-1.2	-1.2	-1.1	-1.0	2.0	2.7	3.4	4.1	3.4	2.8	2.1	1.5	0.8	0.7	0.6	0.4	0.3	0.2
8	-0.7	-1.0	-1.1	-1.2	-0.9	-0.6	-0.3	0.0	1.2	2.3	3.5	2.9	2.4	1.8	1.3	0.7	0.6	0.5	0.4	0.3	0.2
7	-0.7	-1.0	-1.1	-1.2	-0.6	0.0	0.6	1.2	1.8	2.4	3.0	2.5	2.0	1.5	1.0	0.9	0.7	0.6	0.5	0.3	0.2
6	-0.7	-1.0	-1.1	-1.2	-1.1	-1.1	-1.0	-0.3	0.4	1.0	1.7	2.4	2.1	1.9	1.6	1.4	1.1	0.9	0.6	0.4	0.1
5	-0.7	-1.0	-1.2	-1.1	-1.0	-0.6	-0.2	0.1	0.5	0.9	1.4	1.8	1.4	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1
4	-0.9	-1.0	-1.2	-1.0	-0.9	-0.7	-0.5	-0.2	0.2	0.5	0.8	1.1	1.0	0.9	0.8	0.7	0.5	0.4	0.3	0.2	0.1
3	-0.9	-0.9	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0	0.1	0.2	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2	0.1	0.0
2	-0.3	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.4	-0.1	0.0	0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-10(c) Vertical Wind Speed, W_z

Case 10(J) Series No. 2206,

$\overline{W}_x = 13.1\ m\ s^{-1}$, Length of Field L = 8510.8 m, Horizontal Increment Δx = 212.77 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.8	0.6	0.3	0.1	-0.1	0.0	0.0	-0.3	-0.7	-1.0	-1.4	-1.8	-2.1	-2.0	-2.0	-1.7	-1.3	-1.0	-0.7	-0.3	0.0
10	0.8	0.5	0.1	-0.2	-0.1	0.0	0.0	-0.3	-0.6	-0.9	-1.2	-1.5	-1.8	-2.1	-1.8	-1.4	-1.0	-0.7	-0.3	0.0	0.7
9	0.7	0.4	0.0	-0.3	-0.2	0.0	0.0	-0.3	-0.5	-0.8	-1.1	-1.4	-1.6	-1.9	-1.6	-1.3	-0.9	-0.6	-0.3	0.0	0.7
8	0.7	0.4	0.0	-0.3	-0.1	0.2	0.1	-0.1	-0.1	0.0	-0.4	-0.7	-1.1	-1.5	-1.1	-0.7	-0.3	0.1	0.5	0.9	1.4
7	0.7	0.3	0.0	-0.4	0.0	0.3	0.2	0.0	0.0	0.0	-0.3	-0.6	-0.8	-1.1	-0.7	-0.4	0.0	0.4	0.8	1.2	1.6
6	0.6	0.1	-0.4	-0.2	0.1	0.3	0.5	0.3	0.2	0.1	-0.1	-0.3	-0.6	-0.8	-0.4	0.0	0.3	0.7	1.0	1.4	1.8
5	0.6	0.0	-0.2	0.0	0.2	0.5	0.7	0.5	0.3	0.2	0.0	-0.2	-0.3	-0.5	-0.2	0.1	0.4	0.7	1.0	1.4	1.7
4	0.7	0.3	0.0	0.2	0.4	0.6	0.8	0.7	0.5	0.4	0.3	0.1	0.0	0.0	0.0	0.3	0.6	0.9	1.1	1.4	1.7
3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.6	0.4	0.4	0.3	0.2	0.1	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0
2	1.5	2.5	3.4	2.7	2.0	1.8	1.6	1.4	1.2	1.1	0.9	0.7	0.5	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0
1	2.0	3.0	4.1	3.1	2.1	1.9	1.7	1.6	1.4	1.2	1.0	0.9	0.7	0.5	0.7	1.0	1.2	1.4	1.6	1.9	2.1

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.0	1.0	2.0	2.3	2.7	3.0	3.4	3.7	4.1	6.3	8.6	10.8	13.0	13.6	14.1	14.1	14.1	14.1	14.0	14.0	14.0
10	0.7	1.4	2.1	2.4	2.8	3.1	3.4	3.8	4.1	6.1	8.1	10.2	12.2	12.6	12.9	13.3	13.6	14.0	13.9	13.9	13.8
9	0.7	1.4	2.1	2.4	2.7	3.0	3.4	3.7	4.0	5.9	7.9	9.9	11.8	12.1	12.4	12.6	12.9	13.2	13.1	13.1	13.0
8	1.4	1.8	2.1	2.4	2.7	3.1	3.4	3.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	12.1	12.1	12.2	12.3	12.3	12.4
7	1.6	2.0	2.3	2.5	2.8	3.1	3.4	3.6	3.9	5.4	6.9	8.5	10.0	10.2	10.3	10.5	10.6	10.8	11.0	11.1	11.3
6	1.8	2.1	2.1	2.0	2.0	2.0	2.7	3.3	4.0	4.6	5.7	6.8	8.0	9.1	9.2	9.3	9.4	9.6	9.7	9.8	9.9
5	1.7	2.0	2.0	2.0	2.0	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
4	1.7	1.8	1.9	2.0	2.4	2.7	3.1	3.4	3.8	4.1	4.5	5.3	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2
3	2.0	1.9	1.8	1.9	2.0	2.6	3.2	3.8	3.8	3.9	3.9	4.4	4.9	4.8	4.8	4.8	4.7	4.7	4.6	4.6	4.5
2	2.0	1.9	1.8	2.0	2.5	3.0	3.5	4.0	3.8	3.7	3.5	3.3	3.2	3.0	2.9	2.9	2.8	2.7	2.6	2.6	2.5
1	2.1	2.1	2.0	2.0	3.0	4.1	4.1	4.0	4.0	3.6	3.2	2.8	2.4	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9

Table 2A-11(a) Wind Speed in Direction of Frontal Motion, W_x

Case 11(K) Series No. 2118,

$\overline{W}_x = 12.4\ m\ s^{-1}$, Length of Field L = 8163.2 m, Horizontal Increment Δx = 204.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	26.9	25.5	24.1	22.8	21.4	21.1	20.7	20.4	18.4	14.4	14.8	15.2	15.6	16.0	16.4	16.5	16.5	16.4	16.3	15.6	15.0
10	26.6	25.1	23.5	22.0	20.5	20.6	20.7	19.1	17.5	16.0	14.4	14.4	14.4	15.1	15.8	16.5	16.5	16.4	15.9	15.3	14.8
9	26.5	24.9	23.2	21.5	19.9	20.3	20.6	19.4	18.2	17.0	15.8	14.6	15.0	15.4	15.7	16.1	16.5	16.1	15.6	15.2	14.7
8	25.4	23.9	22.4	20.9	19.4	19.9	20.4	19.4	18.4	17.4	16.4	15.6	14.8	15.0	15.2	15.4	15.6	15.3	15.1	14.8	14.6
7	24.4	22.4	20.4	18.4	16.4	17.4	18.3	17.9	17.4	17.0	16.5	15.6	14.8	14.9	15.1	15.3	15.4	15.2	15.0	14.7	14.5
6	22.4	20.4	18.4	16.4	15.9	15.4	15.7	16.0	16.3	16.6	15.9	15.3	14.6	14.6	14.5	14.5	14.5	14.5	14.4	14.4	14.1
5	20.4	19.4	18.4	16.4	14.4	14.4	14.5	14.5	16.3	16.5	15.8	15.1	14.4	14.4	14.3	14.3	14.3	14.2	14.2	13.3	12.4
4	16.4	17.1	15.7	14.4	14.1	13.7	13.4	14.1	14.7	15.4	14.8	14.3	14.0	13.8	13.5	13.2	12.9	12.7	12.4	10.5	10.8
3	16.4	15.7	15.1	14.4	12.3	12.3	12.4	12.4	12.9	13.4	13.1	12.7	12.4	12.4	12.4	12.4	12.4	12.4	11.3	10.3	10.6
2	15.1	13.5	11.9	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.1	9.9
1	14.9	13.6	12.4	10.1	9.5	8.9	8.3	7.7	7.0	6.4	6.8	7.2	7.5	7.9	8.3	8.3	8.3	8.4	8.4	8.4	8.9

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	15.0	14.3	14.4	14.5	14.5	14.4	14.4	14.4	12.4	9.7	7.1	4.4	3.4	2.4	1.2	0.0	-1.2	-2.4	-3.6	-3.7	-3.8
10	14.8	14.3	14.4	14.5	13.9	13.4	13.1	12.9	12.6	10.6	8.6	6.7	4.7	2.7	1.8	0.9	0.0	-1.0	-1.9	-2.8	-3.7
9	14.7	14.3	14.4	14.5	13.4	12.4	12.8	13.1	11.2	9.3	7.3	5.4	4.4	3.4	2.4	1.4	0.4	-0.6	-1.6	-2.6	-3.6
8	14.6	14.3	14.4	14.5	13.4	12.3	12.5	12.8	11.2	9.6	8.1	6.5	4.9	3.3	2.5	1.6	0.8	-0.1	-0.9	-1.8	-2.6
7	14.5	14.3	14.3	14.4	13.3	12.3	12.5	12.8	11.2	9.6	8.0	6.4	5.6	4.8	3.9	3.1	2.3	1.3	0.2	-0.8	-1.8
6	14.1	13.9	13.6	13.4	12.9	12.4	12.6	12.9	10.1	7.3	6.6	5.9	5.2	4.6	3.9	3.2	2.3	1.3	0.4	-0.6	-1.6
5	12.4	12.5	12.6	12.7	12.8	12.9	13.0	13.1	12.4	11.1	9.7	8.4	7.1	5.7	4.4	3.5	2.6	1.6	0.7	-0.2	-1.1
4	10.8	11.1	11.4	11.8	12.1	12.4	12.8	13.2	11.5	9.9	8.8	7.7	6.6	5.5	4.7	4.0	3.2	2.4	1.4	0.4	-0.6
3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	11.5	10.7	9.8	9.0	8.1	7.2	6.3	5.4	4.6	3.9	3.1	2.4	1.4	0.4
2	9.9	10.1	10.3	10.5	10.7	10.9	10.6	10.4	9.7	9.1	8.4	7.7	6.9	6.2	5.7	5.2	4.8	4.3	3.4	2.6	1.7
1	8.9	9.3	9.8	10.3	10.9	10.1	9.3	7.8	6.4	6.4	6.3	6.3	6.3	6.0	5.7	5.3	5.0	4.7	4.4	3.4	2.4

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Table 2A-11(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 11(K) Series No. 2118,

$\overline{W}_x$ = 12.4 m s^{-1}, Length of Field L = 8163.2 m , Horizontal Increment Δx = 204.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.1	-1.0	-0.9	-0.7	-0.6	-0.7	-0.9	-1.0	-1.0	-1.0	-0.4	0.1	-0.5	-1.1	-1.2	-1.3	-1.4	-1.4	-1.5	-1.6	-1.7
10	-1.1	-0.9	-0.7	-0.7	-0.7	-0.7	-0.7	-0.9	-1.1	-1.0	-0.4	0.1	-0.5	-1.1	-1.2	-1.3	-1.4	-1.5	-1.5	-1.5	-1.6
9	-1.1	-0.9	-0.8	-0.8	-0.7	-0.7	-0.7	-0.9	-1.1	-0.7	-0.4	0.0	-0.5	-1.0	-1.1	-1.2	-1.3	-1.4	-1.4	-1.5	-1.6
8	-1.1	-0.9	-0.8	-0.9	-0.9	-0.8	-0.8	-0.9	-1.1	-0.9	-0.6	-0.4	-0.7	-1.0	-1.1	-1.1	-1.2	-1.2	-1.3	-1.3	-1.4
7	-1.2	-1.0	-0.9	-0.9	-1.0	-0.9	-0.9	-1.0	-1.1	-1.0	-1.0	-0.7	-0.5	-0.7	-1.0	-1.1	-1.2	-1.2	-1.2	-1.3	-1.3
6	-1.2	-1.2	-1.1	-1.1	-1.0	-1.0	-0.9	-0.9	-1.1	-1.0	-1.0	-0.9	-0.5	-0.7	-0.9	-1.0	-1.2	-1.1	-1.1	-1.1	-1.2
5	-1.2	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-0.9	-0.5	-0.7	-1.0	-1.2	-1.1	-1.1	-1.0	-1.1	-1.0
4	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-0.6	-0.2	-0.5	-0.8	-1.1	-1.0	-1.0	-0.9	-1.1	-1.0
3	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.6	-0.2	-0.5	-0.7	-1.0	-0.9	-0.9	-0.8	-0.9	-1.0
2	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4	-0.3	-0.2	-0.3	-0.4	-0.6	-0.7	-0.7	-0.7	-0.8	-0.8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.7	-1.8	-1.8	-1.9	-2.0	-2.4	-1.7	-1.0	0.5	2.0	2.5	3.1	2.7	2.4	2.0	1.7	1.3	1.0	1.1	1.2	1.3
10	-1.6	-1.6	-1.7	-2.0	-2.3	-2.6	-1.8	-1.0	0.0	1.0	2.0	3.0	2.7	2.3	2.0	1.6	1.2	0.9	1.0	1.2	1.3
9	-1.6	-1.6	-1.7	-2.1	-2.6	-3.0	-2.0	-1.0	0.0	1.0	2.0	2.2	2.4	1.9	1.5	1.0	0.9	0.9	1.0	1.1	1.3
8	-1.4	-1.4	-1.8	-2.1	-2.5	-3.1	-2.2	-1.4	-0.5	0.4	1.4	1.8	2.1	1.7	1.2	0.8	0.9	0.9	0.9	1.0	1.2
7	-1.3	-1.2	-1.2	-1.9	-2.5	-3.1	-2.5	-2.0	-1.0	0.0	1.0	1.4	1.8	1.4	1.0	0.9	0.7	0.6	0.8	1.0	1.2
6	-1.2	-1.0	-1.4	-1.8	-2.4	-3.0	-2.5	-1.9	-1.4	-0.4	0.5	1.0	1.4	1.1	0.8	0.7	0.7	0.6	0.8	1.0	1.2
5	-1.0	-0.9	-1.0	-1.5	-2.1	-2.6	-2.2	-1.9	-1.5	-0.7	0.0	0.5	1.0	0.9	0.7	0.6	0.5	0.6	0.8	0.9	1.1
4	-1.0	-0.9	-0.8	-1.4	-2.0	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9	0.9	1.0
3	-1.0	-0.8	-1.0	-1.2	-1.4	-1.5	-1.7	-1.4	-1.1	-0.7	-0.3	-0.1	0.2	0.1	0.0	0.1	0.3	0.4	0.5	0.7	0.8
2	-0.8	-0.8	-0.9	-0.9	-0.9	-0.9	-1.0	-0.9	-0.9	-0.6	-0.4	-0.1	0.0	0.1	0.0	-0.1	0.0	0.0	0.1	0.1	0.2
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 2A-11(c) Vertical Wind Speed, W_z

Case 11(K) Series No. 2118,

$\overline{W}_x = 12.4 \text{ m s}^{-1}$, Length of Field L = 8163.2 m, Horizontal Increment Δx = 204.08 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-6.0	-6.0	-6.0	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9	-5.9	-6.0	-6.0	-6.0	-6.0	-6.1	-6.1	-6.1	-6.0	-6.0	-5.8	-5.5
10	-6.1	-6.1	-6.1	-6.0	-6.0	-6.0	-6.0	-6.0	-5.9	-5.9	-5.9	-6.0	-6.0	-6.1	-6.1	-6.1	-6.1	-6.1	-6.0	-6.0	-6.0
9	-6.1	-6.5	-6.8	-7.2	-6.9	-6.5	-6.2	-6.2	-6.1	-6.1	-6.0	-6.0	-6.1	-6.1	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.1
8	-6.2	-6.8	-7.4	-8.0	-7.3	-6.5	-5.8	-6.1	-6.1	-6.1	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.1
7	-6.3	-6.9	-7.4	-8.0	-8.0	-6.0	-5.0	-6.0	-6.1	-6.1	-6.2	-6.2	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.3	-6.2	-6.0
6	-6.3	-6.9	-7.4	-8.0	-6.8	-5.7	-4.0	-5.1	-6.1	-6.2	-6.2	-6.2	-6.3	-6.3	-6.3	-6.2	-6.2	-6.2	-6.2	-6.1	-5.8
5	-6.1	-6.7	-7.4	-8.0	-6.6	-5.2	-3.9	-4.0	-6.0	-6.1	-6.1	-6.2	-6.2	-6.2	-6.2	-6.2	-6.1	-6.1	-6.0	-5.8	-5.6
4	-5.0	-5.5	-6.0	-5.5	-4.9	-4.4	-3.9	-4.6	-5.2	-5.9	-5.9	-5.9	-6.0	-6.0	-6.0	-6.0	-6.0	-5.7	-5.5	-5.2	-4.9
3	-4.0	-4.0	-4.0	-4.0	-4.0	-3.3	-2.7	-2.0	-4.0	-4.3	-4.5	-4.8	-4.4	-4.1	-4.1	-4.1	-4.0	-4.0	-4.1	-4.1	-4.2
2	0.0	0.4	0.9	1.3	-0.3	-2.0	-0.1	1.8	0.3	-1.1	-2.5	-4.0	-3.0	-2.0	-3.0	-4.0	-1.5	1.0	0.0	-1.0	-2.0
1	1.0	2.0	3.0	4.0	2.0	0.0	2.0	4.0	4.0	1.0	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-0.1	2.0	0.6	-0.7	-2.1

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-5.5	-5.3	-5.0	-4.8	-4.5	-4.3	-4.5	-4.8	-5.0	-5.2	-5.4	-5.7	-5.9	-7.2	-8.5	-9.2	-9.9	-10.1	-10.2	-10.1	-10.1
10	-6.0	-5.9	-5.9	-5.3	-4.6	-4.0	-4.3	-4.5	-4.8	-5.1	-5.4	-5.6	-5.9	-7.1	-8.2	-8.9	-9.5	-10.2	-10.2	-10.1	-10.1
9	-6.1	-6.0	-6.0	-5.3	-4.7	-4.0	-4.0	-4.3	-4.6	-4.9	-5.3	-5.6	-5.9	-6.9	-8.0	-8.7	-9.3	-10.0	-10.1	-10.1	-10.0
8	-6.1	-6.1	-6.0	-6.0	-5.0	-4.0	-4.3	-4.5	-4.8	-5.1	-5.4	-5.6	-5.9	-6.4	-6.9	-7.5	-8.0	-9.1	-10.1	-9.9	-9.8
7	-6.0	-6.0	-6.0	-5.3	-4.7	-4.0	-4.3	-4.5	-4.8	-5.0	-5.3	-5.5	-5.8	-6.3	-6.8	-7.4	-7.9	-8.5	-9.1	-9.7	-9.3
6	-5.8	-5.6	-5.3	-5.0	-4.7	-4.5	-4.2	-4.4	-4.6	-4.8	-5.1	-5.3	-5.5	-6.0	-6.5	-7.0	-7.5	-8.0	-8.3	-8.6	-8.9
5	-5.6	-5.4	-5.2	-5.0	-4.8	-4.6	-4.4	-4.6	-4.8	-5.0	-5.2	-5.4	-5.6	-5.8	-6.0	-6.4	-6.8	-7.2	-7.6	-8.0	-8.1
4	-4.9	-4.7	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.4	-4.3	-4.3	-4.9	-5.4	-6.0	-6.3	-6.5	-6.8	-7.0	-7.3
3	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.2	-4.1	-4.0	-4.5	-5.0	-5.5	-6.0	-6.1	-6.2	-6.4	-6.5
2	-2.0	-3.0	-3.3	-3.5	-3.8	-4.1	-4.1	-4.0	-4.0	-3.7	-3.3	-3.0	-2.7	-2.5	-2.2	-2.8	-3.4	-4.0	-4.3	-4.7	-5.0
1	-2.1	-2.0	-2.0	-2.0	-2.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.0	-2.0	-2.0	-2.0	-2.0	-2.5	-3.0	-3.5	-4.0	-4.2

Table 2A-12(a) Wind Speed in Direction of Frontal Motion, W_x

Case 12(L) Series No. 1759,

$\overline{W}_x = 5.5$ m s^{-1}, Length of Field L = 3636.0 m, Horizontal Increment Δx = 90.90 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	9.3	8.9	8.6	8.2	7.9	7.5	7.1	6.7	6.3	5.9	5.5	4.5	3.4	4.5	5.5	5.9	6.3	6.0	5.7	3.6	1.5
10	9.6	9.6	9.5	9.5	8.6	7.6	7.4	7.5	7.6	7.0	6.3	5.7	5.0	5.7	6.3	6.1	6.0	5.8	5.7	5.5	3.5
9	10.6	10.2	9.7	9.3	8.8	8.3	7.7	7.6	7.6	7.5	6.9	6.4	5.8	6.7	7.5	7.1	6.8	6.4	6.1	5.7	4.3
8	11.5	10.9	10.4	9.9	9.3	9.1	8.9	8.6	8.4	8.2	8.0	7.7	7.5	7.6	7.6	7.3	6.9	6.6	6.3	5.9	5.6
7	11.6	11.1	10.5	9.9	9.4	9.2	8.9	8.7	8.5	8.3	8.1	7.8	7.6	7.6	7.6	7.4	7.1	6.8	6.5	6.2	5.9
6	11.7	11.2	10.6	10.1	9.5	8.6	7.7	7.7	7.7	7.7	7.7	7.6	7.6	7.6	7.6	7.4	7.1	6.9	6.6	6.3	6.0
5	11.5	11.0	10.5	10.0	9.5	8.4	7.4	7.5	7.5	7.6	7.6	7.7	7.7	7.6	7.5	7.4	7.1	6.9	6.6	6.4	6.1
4	11.0	10.9	10.7	10.0	9.3	8.0	6.6	6.6	6.5	6.5	7.5	7.6	7.7	7.7	7.6	7.3	7.1	6.8	6.5	6.3	6.1
3	10.6	11.1	11.5	10.2	8.8	7.5	5.5	5.5	5.5	5.5	6.6	7.6	7.5	7.5	7.4	7.2	7.0	6.9	6.7	6.5	6.5
2	10.4	10.9	11.5	10.1	8.8	7.4	6.1	4.8	3.5	4.9	6.2	7.6	7.4	7.3	7.1	6.9	6.7	6.6	6.4	6.6	6.8
1	10.3	10.9	11.6	10.2	8.8	6.3	3.9	3.6	3.3	4.4	5.5	5.6	5.7	5.8	6.0	6.1	6.2	6.3	6.4	6.6	6.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	1.5	-0.4	-2.4	-2.6	-2.4	-2.3	-2.4	-2.5	-2.6	-3.3	-3.9	-4.6	-5.1	-5.6	-6.0	-6.5	-6.5	-6.6	-6.6	-6.7	-6.7
10	3.5	1.5	-0.5	-1.5	-1.7	-1.8	-2.0	-2.1	-2.3	-2.9	-3.4	-3.9	-4.5	-4.8	-5.2	-5.5	-5.8	-6.2	-6.5	-6.6	-6.7
9	4.3	2.9	1.5	0.5	-0.5	-0.6	-0.7	-0.8	-1.7	-2.5	-3.0	-3.6	-4.1	-4.6	-4.7	-4.8	-4.9	-5.0	-5.5	-6.0	-6.5
8	5.6	4.6	3.5	1.7	-0.2	-0.3	-0.5	-0.7	-0.8	-1.7	-2.5	-2.9	-3.3	-3.7	-4.1	-4.2	-4.4	-4.5	-4.9	-5.3	-5.7
7	5.9	5.6	4.0	2.6	1.2	0.8	0.3	-0.1	-0.5	-1.0	-1.6	-2.1	-2.6	-2.9	-3.2	-3.5	-3.8	-4.1	-4.4	-4.9	-5.5
6	6.0	5.8	5.5	4.0	2.4	1.8	1.3	0.7	0.1	-0.5	-1.0	-1.6	-2.1	-2.6	-2.9	-3.2	-3.6	-3.9	-4.2	-4.5	-5.0
5	6.1	5.9	5.6	4.6	3.5	2.8	2.0	1.3	0.8	0.4	-0.1	-0.5	-1.1	-1.8	-2.4	-2.5	-2.6	-3.2	-3.8	-4.3	-4.7
4	6.1	5.9	5.7	5.5	5.0	4.2	3.4	2.3	1.3	0.9	0.5	0.2	-0.2	-0.6	-1.0	-1.7	-2.3	-3.0	-3.7	-4.7	-4.5
3	6.5	6.5	6.4	6.4	6.4	5.5	4.2	2.8	1.5	1.4	1.4	1.3	0.4	-0.5	-1.1	-1.7	-2.3	-2.9	-3.5	-4.7	-4.5
2	6.8	7.1	7.3	7.5	6.8	6.1	5.4	3.5	3.0	2.5	2.0	1.5	0.8	0.2	-0.5	-1.2	-2.0	-2.8	-3.5	-4.7	-4.5
1	6.7	7.0	7.3	7.5	7.8	6.7	5.5	3.4	3.0	2.6	2.3	1.9	1.5	0.8	0.0	-0.7	-1.7	-2.6	-3.6	-4.7	-4.3

Table 2A-12(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 12(L) Series No. 1759,

$\overline{W}_x$ =5.5 m s^{-1}, Length of Field L = 3636.0 m, Horizontal Increment Δx = 90.90 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	2.1	1.5	1.0	0.4	-0.1	-1.0	-1.0	-1.0	-1.1	-1.1	-1.1	-1.1	-1.1	-1.2	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	1.5
10	2.1	1.6	1.1	0.6	0.1	-0.3	-0.8	-0.8	-0.9	-0.9	-1.0	-1.0	-1.1	-1.1	-1.0	-1.0	-0.7	-0.5	-0.2	0.0	1.0
9	2.0	1.6	1.2	0.8	0.4	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.7	-0.9	-1.0	-1.1	-0.9	-0.7	-0.5	-0.3	-0.1	0.4
8	1.5	1.2	1.0	0.7	0.5	0.2	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.7	-0.9	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0
7	1.2	1.1	1.0	0.8	0.6	0.4	0.2	0.0	0.0	0.0	-0.2	-0.3	-0.5	-0.6	-0.8	-0.7	-0.5	-0.4	-0.3	-0.2	0.0
6	1.1	1.0	0.8	0.7	0.6	0.5	0.3	0.2	0.1	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.5	-0.4	-0.4	-0.3	-0.2	-0.2
5	0.9	0.7	0.4	0.2	0.2	0.1	0.1	0.1	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.1
4	0.5	0.3	0.2	0.0	0.1	0.1	0.2	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
3	0.3	0.2	0.0	-0.1	0.0	0.1	0.1	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
2	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	1.5	3.0	3.1	3.1	3.2	3.2	3.3	2.9	2.5	2.1	1.9	1.8	1.6	1.4	1.2	1.1	0.9	0.9	1.0	1.0	1.1
10	1.0	2.0	2.9	3.0	3.0	3.0	3.1	2.7	2.4	2.0	1.9	1.7	1.5	1.4	1.2	1.1	0.9	0.9	1.0	1.0	1.1
9	0.4	1.0	2.0	2.0	2.0	2.5	2.9	2.5	2.0	1.8	1.5	1.2	1.0	1.0	1.1	1.0	0.9	0.9	1.0	1.0	1.1
8	0.0	0.5	1.0	1.2	1.5	2.0	2.5	2.2	1.8	1.5	1.3	1.0	0.9	0.8	0.9	1.0	0.9	0.9	1.0	1.0	1.1
7	0.0	0.1	0.4	0.8	1.1	1.6	2.1	1.8	1.5	1.3	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.9	0.9
6	-0.2	-0.1	0.0	0.4	0.9	1.4	1.8	1.5	1.3	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.4
5	-0.1	-0.1	0.0	0.0	0.5	1.0	1.5	1.4	1.2	1.1	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1	0.0	0.0	0.0
4	-0.1	-0.1	0.0	0.0	0.3	0.7	1.0	0.9	0.7	0.6	0.4	0.3	0.1	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1
3	-0.1	-0.1	0.0	0.0	0.2	0.3	0.5	0.4	0.4	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1
2	-0.1	-0.1	0.0	0.0	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-12(c) Vertical Wind Speed. W_z

Case 12(L) Series No. 1759,

$\overline{W}_x = 5.5\ m\ s^{-1}$, Length of Field L = 3636.0 m, Horizontal Increment Δx = 90.90 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.0	-1.0	-2.0	-2.3	-2.6	-2.9	-3.1	-3.4	-3.7	-4.0	-4.2	-4.4	-4.7	-4.9	-5.1	-5.3	-5.6	-5.8	-6.0	-6.0	-5.0
10	0.0	-0.7	-1.5	-2.2	-2.5	-2.8	-3.1	-3.4	-3.7	-4.0	-4.3	-4.5	-4.8	-5.0	-5.3	-5.5	-5.8	-6.0	-6.0	-6.0	-5.0
9	0.0	-0.7	-1.3	-2.0	-2.3	-2.7	-3.0	-3.4	-3.7	-4.1	-4.4	-4.6	-4.9	-5.1	-5.4	-5.6	-5.9	-6.0	-6.1	-6.0	-5.3
8	-0.6	-1.1	-1.5	-2.0	-2.4	-2.7	-3.1	-3.4	-3.8	-4.1	-4.3	-4.6	-4.9	-5.2	-5.4	-5.7	-6.0	-6.1	-6.1	-6.0	-5.9
7	-1.0	-1.3	-1.7	-2.0	-2.4	-2.8	-3.1	-3.5	-3.9	-4.2	-4.5	-4.8	-5.1	-5.4	-5.7	-6.0	-6.0	-6.1	-6.1	-6.0	-5.9
6	-1.7	-1.8	-2.0	-2.1	-2.5	-2.8	-3.2	-3.5	-3.9	-4.2	-4.5	-4.8	-5.2	-5.5	-5.8	-6.1	-6.1	-6.2	-6.2	-6.1	-6.0
5	-2.0	-2.2	-2.4	-2.6	-2.9	-3.2	-3.4	-3.7	-4.0	-4.3	-4.7	-5.0	-5.3	-5.7	-6.0	-6.1	-6.1	-6.2	-6.2	-6.1	-6.1
4	-2.8	-3.0	-3.2	-3.2	-3.2	-3.4	-3.6	-3.8	-4.0	-4.4	-4.8	-5.2	-5.6	-6.0	-6.1	-6.1	-6.2	-6.2	-6.3	-6.2	-6.2
3	-3.2	-3.6	-3.4	-3.2	-3.0	-3.3	-3.7	-4.0	-4.4	-4.8	-5.2	-5.6	-6.0	-6.1	-6.1	-6.2	-6.3	-6.3	-6.4	-6.3	-6.3
2	-3.8	-4.0	-3.7	-3.3	-3.0	-3.3	-3.7	-4.0	-4.5	-4.9	-5.4	-5.9	-6.0	-6.0	-6.1	-6.2	-6.2	-6.3	-6.3	-6.4	-6.4
1	-4.0	-4.0	-4.0	-3.6	-3.2	-3.6	-4.0	-4.4	-4.8	-5.2	-5.6	-6.0	-6.1	-6.1	-6.2	-6.2	-6.3	-6.3	-6.4	-6.4	-6.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-5.0	-4.0	-3.0	-2.0	-1.8	-1.6	-1.3	-1.1	-0.9	-0.7	-0.4	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	2.0
10	-5.0	-4.0	-3.3	-2.5	-1.8	-1.6	-1.5	-1.3	-1.1	-0.9	-0.6	-0.4	-0.2	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0
9	-5.3	-4.7	-4.0	-3.0	-2.0	-1.8	-1.7	-1.5	-1.3	-1.1	-0.9	-0.6	-0.4	-0.2	0.0	0.0	0.0	0.0	0.7	1.3	2.0
8	-5.9	-5.2	-4.5	-3.8	-2.8	-1.9	-2.0	-2.0	-1.8	-1.7	-1.5	-1.4	-1.2	-1.1	-0.9	-0.6	-0.3	-0.1	0.2	0.9	1.7
7	-5.9	-5.3	-4.6	-4.0	-3.0	-2.0	-2.1	-2.2	-2.2	-2.1	-2.0	-2.0	-1.7	-1.4	-1.1	-0.7	-0.4	-0.1	0.2	0.9	1.5
6	-6.0	-5.5	-4.9	-4.4	-3.9	-3.0	-2.8	-2.7	-2.5	-2.4	-2.3	-2.1	-1.8	-1.5	-1.2	-0.8	-0.5	-0.2	0.1	0.7	1.3
5	-6.1	-6.0	-5.3	-4.7	-4.0	-3.7	-3.5	-3.3	-3.0	-2.8	-2.5	-2.3	-2.0	-1.7	-1.3	-1.0	-0.7	-0.3	0.0	0.5	1.0
4	-6.2	-6.1	-6.1	-6.0	-5.5	-5.0	-4.5	-4.0	-3.7	-3.3	-3.0	-2.6	-2.3	-1.9	-1.5	-1.1	-0.8	-0.4	0.0	0.4	0.9
3	-6.3	-6.2	-6.1	-6.1	-6.0	-6.0	-5.3	-4.7	-4.0	-3.6	-3.2	-2.8	-2.4	-2.0	-1.6	-1.2	-0.8	-0.4	0.0	0.3	0.7
2	-6.4	-6.5	-6.6	-6.7	-6.8	-6.3	-5.7	-5.2	-4.2	-3.2	-2.9	-2.6	-2.3	-2.0	-1.7	-1.3	-0.9	-0.4	0.0	0.2	0.5
1	-6.5	-7.0	-7.5	-8.0	-8.0	-8.0	-7.0	-6.0	-4.9	-3.9	-3.5	-3.1	-2.8	-2.4	-2.0	-1.5	-1.0	-0.5	0.0	0.2	0.3

Table 2A-13(a) Wind Speed in Direction of Frontal Motion, W_x

Case 13(M) Series No. 0211,

$\overline{W}_x = 9.6$ m s^{-1}, Lenght of Field L = 6349.2 m, Horizontal Increment Δx = 158.73 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	9.3	9.7	10.1	10.5	10.8	11.2	11.6	11.7	11.7	11.6	11.5	11.6	11.7	11.7	11.7	11.6	11.5	12.1	12.7	13.3	13.9
10	8.8	9.5	10.1	10.3	10.6	10.8	11.1	11.3	11.2	11.1	11.2	11.3	11.3	11.4	11.5	11.6	11.6	11.7	12.2	12.7	13.1
9	8.6	9.2	9.7	10.3	10.2	10.2	10.1	10.0	10.0	9.9	10.0	10.2	10.3	10.5	10.6	10.7	10.8	11.3	11.8	12.2	12.7
8	8.3	8.9	9.6	10.2	9.9	9.6	9.6	9.5	9.5	9.4	9.6	9.8	10.0	9.9	9.7	10.2	10.8	11.3	11.7	12.1	12.5
7	7.7	8.4	9.0	9.7	9.6	9.4	9.3	9.1	8.9	9.1	9.3	9.4	9.6	9.6	9.5	9.7	9.9	10.8	11.6	11.7	11.7
6	7.6	8.0	8.5	8.9	8.8	8.7	8.5	8.4	8.3	8.4	8.6	8.7	8.8	9.0	9.2	9.4	9.6	10.2	10.9	11.5	11.5
5	6.3	7.1	7.8	7.8	7.7	7.7	7.7	7.6	7.6	7.7	7.9	8.0	8.1	8.2	8.4	8.5	8.6	9.5	10.4	10.5	10.6
4	6.3	6.5	6.8	7.0	7.2	7.1	7.0	6.9	6.8	7.1	7.3	7.6	7.6	7.6	7.5	7.5	8.1	8.6	9.3	9.9	9.8
3	5.6	5.7	5.8	5.8	5.9	5.9	5.9	5.8	5.8	6.0	6.3	6.5	6.7	6.7	6.7	6.6	6.6	7.5	8.1	8.7	8.5
2	5.4	5.4	5.4	5.5	5.5	5.5	5.4	5.2	5.1	5.5	6.0	6.4	6.0	5.6	5.8	6.0	6.2	6.4	6.6	7.5	7.5
1	5.3	5.0	4.8	4.5	4.2	4.0	3.7	3.6	3.5	3.8	4.1	5.7	5.6	5.5	5.5	5.5	5.4	5.4	5.4	5.5	5.6

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	13.9	13.3	12.6	9.6	6.6	3.6	3.3	2.9	2.6	2.2	1.9	1.5	1.0	0.5	0.0	-0.5	-0.2	0.1	0.3	0.6	0.9
10	13.1	13.6	11.6	9.6	7.6	5.6	3.5	3.0	2.6	2.1	1.6	1.4	1.2	0.9	0.7	0.5	0.6	0.7	0.9	1.0	1.1
9	12.7	12.7	12.6	10.6	8.6	6.3	3.9	3.3	2.7	2.1	1.5	1.3	1.2	1.0	0.9	0.7	0.9	1.1	1.3	1.4	1.4
8	12.5	12.2	11.9	11.6	9.5	7.4	5.4	3.3	2.7	2.1	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.4
7	11.7	11.6	11.6	11.5	9.6	7.6	5.6	3.6	2.6	1.6	1.5	1.5	1.4	1.4	1.3	1.4	1.6	1.7	1.6	1.5	1.4
6	11.5	11.4	11.4	10.5	9.6	7.9	6.1	4.4	3.0	1.6	1.5	1.5	1.4	1.4	1.3	1.7	2.0	1.9	1.7	1.6	1.4
5	10.6	10.3	10.1	9.8	9.5	8.0	6.4	5.0	3.6	3.1	2.6	2.7	2.8	2.2	1.6	2.0	2.3	2.7	2.3	2.0	1.6
4	9.8	9.6	9.5	9.4	6.6	7.8	6.6	5.4	4.5	3.6	3.6	3.5	3.5	3.4	3.2	3.0	2.8	2.5	2.3	2.1	1.9
3	8.5	8.3	8.2	8.0	7.8	7.6	6.6	5.5	5.1	4.8	4.4	4.1	3.9	3.6	3.6	3.5	3.3	3.0	2.8	2.5	2.3
2	7.5	7.5	7.4	7.4	7.4	6.5	5.6	5.3	5.0	4.7	4.5	4.3	4.2	4.0	3.8	3.6	3.4	3.1	2.9	2.6	2.4
1	5.6	5.6	5.6	5.5	5.5	5.4	5.2	5.1	5.3	5.4	5.6	5.7	5.2	4.7	4.1	3.6	3.5	3.4	3.3	3.2	3.1

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Table 2A-13(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 13(M) Series No. 0211,

$\overline{W}_x$ = 9.6 m s^{-1}, Length of Field L = 6349.2 m, Horizontal Increment Δx = 158.73 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.2	0.1	-0.1	-0.2	-0.6	-1.1	-1.0	-1.0	-0.9	-0.9	-1.0	-1.2	-1.3	-1.2
10	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.3	0.2	0.0	-0.2	-0.4	-0.6	-0.8	-0.8	-0.7	-0.7	-0.9	-1.0	-1.2	-1.1
9	0.1	0.2	0.3	0.3	0.4	0.5	0.4	0.2	0.1	-0.1	-0.2	-0.4	-0.7	-0.7	-0.7	-0.8	-0.8	-0.9	-1.0	-0.9	-0.9
8	0.1	0.2	0.3	0.4	0.5	0.6	0.5	0.3	0.2	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.6
7	0.0	0.2	0.3	0.4	0.6	0.5	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.5
6	0.0	0.1	0.2	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	-0.1	-0.3	-0.4	-0.3	-0.2
5	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	-0.2	-0.4	-0.3	-0.1
4	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	-0.2	-0.3	-0.2	-0.1
3	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1
2	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.2	-1.1	-1.0	0.7	2.5	3.3	4.2	4.2	4.2	4.1	4.1	3.9	3.0	3.0	3.1	3.1	2.9	2.7	2.4	2.2	2.0
10	-1.1	-1.0	-0.4	0.2	1.5	2.7	4.0	4.0	4.1	4.1	3.8	3.6	3.0	2.5	2.7	2.8	2.4	2.0	1.8	1.7	1.5
9	-0.9	-0.6	-0.2	0.1	1.5	3.0	3.0	3.1	3.1	4.0	3.6	3.1	2.7	2.5	2.4	2.2	2.0	1.9	1.6	1.3	1.0
8	-0.6	-0.4	-0.2	0.0	1.0	1.8	2.5	2.8	3.0	3.2	3.4	3.0	2.4	1.8	1.8	1.7	1.7	1.5	1.3	1.1	0.9
7	-0.5	-0.3	-0.2	0.0	0.7	1.3	2.0	2.4	2.7	3.1	2.7	2.4	2.0	1.6	1.2	1.2	1.3	1.3	1.2	1.0	0.9
6	-0.2	-0.1	0.0	0.1	0.2	0.9	1.3	1.6	2.0	2.4	2.8	2.2	1.6	1.0	0.9	1.0	1.0	1.1	1.0	0.9	0.8
5	-0.1	0.0	-0.1	-0.1	0.0	0.4	0.8	1.3	1.7	2.1	1.8	1.5	1.2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6
4	-0.1	0.0	-0.1	-0.2	0.0	0.2	0.4	0.6	0.9	1.1	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4
3	-0.1	0.0	-0.1	-0.1	0.1	0.2	0.4	0.5	0.7	0.8	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-13(c) Vertical Wind Speed, W_z

Case 13(M) Series No. 0211,

$\overline{W}_x = 9.6 \text{ m s}^{-1}$, Length of Field L = 6349.2 m, Horizontal Increment Δx = 158.73 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.2	0.1	-0.1	-0.2	-0.6	-1.1	-1.0	-1.0	-0.9	-0.9	-1.0	-1.2	-1.3	-1.2
10	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.3	0.2	0.0	-0.2	-0.4	-0.6	-0.8	-0.8	-0.7	-0.7	-0.9	-1.0	-1.2	-1.1
9	0.1	0.2	0.3	0.3	0.4	0.5	0.4	0.2	0.1	-0.1	-0.2	-0.4	-0.7	-0.7	-0.7	-0.8	-0.8	-0.9	-1.0	-0.9	-0.9
8	0.1	0.2	0.3	0.4	0.5	0.6	0.5	0.3	0.2	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.6
7	0.0	0.2	0.3	0.4	0.6	0.5	0.4	0.2	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.5
6	0.0	0.1	0.2	0.3	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	-0.1	-0.3	-0.4	-0.3	-0.2
5	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	-0.2	-0.4	-0.3	-0.1
4	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	-0.2	-0.3	-0.2	-0.1
3	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1
2	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.2	-1.1	-1.0	0.7	2.5	3.3	4.2	4.2	4.2	4.1	4.1	3.9	3.0	3.0	3.1	3.1	2.9	2.7	2.4	2.2	2.0
10	-1.1	-1.0	-0.4	0.2	1.5	2.7	4.0	4.0	4.1	4.1	3.8	3.6	3.0	2.5	2.7	2.8	2.4	2.0	1.8	1.7	1.5
9	-0.9	-0.6	-0.2	0.1	1.5	3.0	3.0	3.1	3.1	4.0	3.6	3.1	2.7	2.5	2.4	2.2	2.0	1.9	1.6	1.3	1.0
8	-0.6	-0.4	-0.2	0.0	1.0	1.8	2.5	2.8	3.0	3.2	3.4	3.0	2.4	1.8	1.8	1.7	1.7	1.5	1.3	1.1	0.9
7	-0.5	-0.3	-0.2	0.0	0.7	1.3	2.0	2.4	2.7	3.1	2.7	2.4	2.0	1.6	1.2	1.2	1.3	1.3	1.2	1.0	0.9
6	-0.2	-0.1	0.0	0.1	0.2	0.9	1.3	1.6	2.0	2.4	2.8	2.2	1.6	1.0	0.9	1.0	1.0	1.1	1.0	0.9	0.8
5	-0.1	0.0	-0.1	-0.1	0.0	0.4	0.8	1.3	1.7	2.1	1.8	1.5	1.2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6
4	-0.1	0.0	-0.1	-0.2	0.0	0.2	0.4	0.6	0.9	1.1	1.3	1.1	1.0	0.9	0.9	0.8	0.7	0.6	0.6	0.5	0.4
3	-0.1	0.0	-0.1	-0.1	0.1	0.2	0.4	0.5	0.7	0.8	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-14(a) Wind Speed in Direction of Frontal Motion, W_x

Case 14(N) Series No. 0109,

$\overline{W}_x = 8.0\ m\ s^{-1}$, Length of Field L = 5128.4 m , Horizontal Increment Δx = 128.21 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	1.5	1.4	1.2	1.0	0.9	0.7	0.6	0.4	0.3	0.2	0.0	0.0	0.0	1.0	2.0	2.5	3.0	3.5	4.0	4.0	4.0
10	1.8	1.6	1.5	1.3	1.1	1.0	0.8	0.6	0.5	0.3	0.2	0.0	0.7	1.3	2.0	2.4	2.8	3.2	3.6	4.0	4.0
9	2.0	1.8	1.6	1.5	1.3	1.1	0.9	0.7	0.6	0.4	0.2	0.6	1.1	1.5	2.0	2.4	2.8	3.2	3.6	4.0	4.0
8	2.0	1.8	1.7	1.5	1.4	1.2	1.0	0.9	0.7	0.6	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	3.4
7	2.0	1.9	1.8	1.6	1.5	1.4	1.3	1.2	1.0	0.9	0.8	1.2	1.5	1.9	2.2	2.4	2.7	2.9	3.2	3.4	2.9
6	2.0	1.8	1.7	1.5	1.3	1.2	1.0	0.8	0.7	0.5	0.9	1.2	1.6	2.0	2.1	2.2	2.3	2.4	2.5	2.3	2.2
5	1.8	1.6	1.4	1.3	1.1	0.9	0.7	0.6	0.4	0.2	0.6	1.1	1.5	2.0	2.0	2.1	2.1	2.2	2.2	2.1	2.0
4	1.3	1.1	1.0	0.8	0.6	0.5	0.3	0.2	0.0	0.0	0.0	0.0	0.3	0.7	1.0	1.2	1.5	1.8	2.0	1.5	1.0
3	0.9	0.8	0.6	0.5	0.4	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.7	1.0	1.1	1.1	1.2	0.8	0.4
2	0.9	0.8	0.6	0.5	0.4	0.3	0.1	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.9	0.6	0.3
1	0.8	0.7	0.6	0.5	0.3	0.2	0.1	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.1	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	4.0	4.0	4.0	2.0	2.0	3.0	4.0	5.5	7.0	8.5	10.0	10.4	10.8	11.2	11.6	12.0	12.1	12.1	12.1	12.0	12.0
10	4.0	4.0	3.0	2.0	1.2	1.6	2.0	3.3	4.7	6.5	8.3	9.1	9.8	10.6	11.1	11.5	12.0	12.0	12.0	12.0	11.3
9	4.0	3.9	3.1	2.3	1.6	0.8	1.4	2.0	4.0	6.0	8.0	8.5	9.0	9.5	10.0	11.0	12.0	12.0	12.0	12.0	11.0
8	3.4	2.7	2.1	1.4	0.7	0.0	1.0	2.0	3.0	5.0	7.0	7.5	8.0	8.8	9.6	10.4	10.7	11.0	10.8	10.7	10.5
7	2.9	2.5	2.0	1.0	0.0	0.0	0.0	1.0	2.0	4.1	6.2	6.6	7.0	8.0	8.7	9.3	10.0	10.0	10.1	10.1	10.1
6	2.2	2.0	1.0	0.1	0.0	0.0	0.0	0.0	2.0	4.0	6.0	6.0	6.0	7.0	8.0	8.6	9.1	9.1	9.1	9.0	9.0
5	2.0	1.3	0.7	0.0	-0.1	-0.1	-0.1	0.0	0.0	2.3	4.7	5.1	5.6	6.0	6.7	7.3	8.0	8.0	8.1	8.1	8.1
4	1.0	0.5	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	2.0	3.9	4.0	4.0	4.1	5.1	6.0	6.0	6.1	6.1	6.7	7.2
3	0.4	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	1.0	2.0	2.5	3.0	3.5	4.0	4.4	4.8	5.1	5.5	5.9	6.2
2	0.3	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.4	0.8	1.2	1.6	2.0	2.5	3.0	3.5	4.0	4.6	5.1
1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0

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Table 2A-14(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 14(N) Series No. 0109,

$\overline{W}_x$ = 8.0 m s^{-1}, Length of Field L = 5128.4 m, Horizontal Increment Δx = 128.21 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	8.8	9.1	9.4	9.7	10.0	10.0	10.0	9.9	9.8	9.9	9.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
10	8.9	9.3	9.6	10.0	10.1	10.1	10.1	10.0	10.0	10.0	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.1	10.0	10.0
9	8.9	9.3	9.7	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.1	10.1
8	8.8	9.2	9.6	10.0	10.0	10.0	10.1	10.1	10.1	10.1	10.1	10.1	10.1	10.2	10.2	10.2	10.2	10.2	10.2	10.1	10.0
7	8.6	9.0	9.3	9.5	9.8	10.0	10.0	10.0	9.9	9.9	9.9	10.0	10.1	10.1	10.1	10.1	10.2	10.2	10.2	10.2	10.2
6	8.4	8.5	8.7	8.8	8.9	9.1	9.2	9.3	9.5	9.6	9.7	9.9	10.0	10.0	10.1	10.1	10.1	10.1	10.2	10.2	10.2
5	8.0	8.0	8.0	8.1	8.3	8.4	8.5	8.6	8.7	8.9	9.0	9.3	9.7	10.0	10.0	10.1	10.1	10.1	10.1	10.2	10.2
4	7.0	7.3	7.7	8.0	8.0	8.0	8.0	8.1	8.1	8.1	8.1	8.5	8.8	9.2	9.5	9.9	9.9	9.9	9.9	9.9	10.0
3	6.0	6.2	6.4	6.6	6.7	6.9	7.1	7.3	7.4	7.6	7.8	8.0	8.1	8.3	8.4	8.5	8.6	8.8	8.9	8.7	8.6
2	3.9	3.9	3.9	4.0	4.0	4.0	4.7	5.3	6.0	6.2	6.5	6.7	6.8	6.9	7.0	7.2	7.3	7.5	7.2	6.9	6.6
1	3.8	3.8	3.9	3.9	3.9	4.0	4.0	4.4	4.8	5.3	5.7	6.1	6.0	5.8	5.7	5.8	6.0	6.1	5.9	5.4	4.9

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	10.0	10.0	10.0	9.0	8.0	6.0	4.0	2.1	0.1	-0.1	-0.2	-0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
10	10.0	10.0	9.9	9.9	8.4	7.0	5.1	3.2	1.3	0.5	-0.3	-0.3	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9
9	10.1	10.1	10.0	10.0	9.0	8.0	6.0	4.0	2.0	0.9	-0.1	-0.3	-0.5	-0.7	-0.9	-1.1	-1.2	-1.4	-1.6	-1.8	-2.0
8	10.0	9.9	9.9	9.8	9.7	8.3	6.9	5.0	3.0	1.5	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1
7	10.2	10.1	10.1	10.0	10.0	8.5	7.0	5.5	4.0	2.1	0.1	-0.4	-0.9	-1.5	-2.0	-2.0	-2.1	-2.1	-2.1	-2.2	-2.2
6	10.2	10.1	10.1	10.0	10.0	9.0	8.0	6.4	4.8	3.2	1.6	0.0	-0.5	-1.1	-1.6	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1
5	10.2	10.2	10.1	10.1	10.0	9.1	8.3	6.7	5.1	3.5	1.9	0.9	0.0	-0.5	-1.0	-1.5	-2.0	-2.0	-2.1	-2.1	-2.1
4	10.0	10.0	10.0	10.0	9.3	8.6	7.9	7.2	5.8	4.4	3.0	1.6	0.8	0.0	-0.4	-0.8	-1.1	-1.5	-1.9	-2.0	-2.1
3	8.6	8.4	8.3	8.1	8.0	8.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0	-0.3	-0.6	-0.9	-1.2	-1.5	-1.8
2	6.6	6.3	6.0	6.0	6.1	6.1	6.1	6.2	6.0	5.7	4.5	3.2	2.0	1.4	0.9	0.3	-0.2	-0.5	-0.9	-1.2	-1.5
1	4.9	4.4	3.9	3.9	4.0	4.0	5.0	6.0	6.2	5.5	4.7	4.0	3.2	2.4	1.6	0.8	0.0	-0.3	-0.6	-1.0	-1.3

Table 2A-14(c) Vertical Wind Speed, W_z

Case 14(N) Series No. 0109,

$\overline{W}_x = 8.0 \text{ m s}^{-1}$, Length of Field L = 5128.4 m , Horizontal Increment Δx = 128.21 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	1.2	0.3	-0.1	-0.5	-0.9	-0.9	-1.0	0.1	0.1	0.0	-0.2	-0.4	-0.6	-0.8	-1.0	-1.0	-1.1	-1.1	-1.0	-1.0	-0.6
10	1.1	0.0	-0.2	-0.5	-0.7	-1.0	-1.0	0.1	0.1	0.0	-0.2	-0.4	-0.6	-0.8	-1.0	-1.0	-1.1	-1.1	-1.0	-1.0	-0.7
9	1.1	0.0	-0.2	-0.5	-0.7	-1.0	-0.7	-0.3	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.9	-1.0	-1.0	-1.1	-1.1	-0.8	-0.6
8	1.1	0.0	-0.2	-0.3	-0.5	-0.7	-0.5	-0.4	-0.2	-0.3	-0.4	-0.5	-0.7	-0.8	-0.9	-1.0	-1.0	-1.1	-1.0	-0.8	-0.6
7	1.0	0.0	-0.1	-0.2	-0.4	-0.5	-0.4	-0.3	-0.2	-0.3	-0.4	-0.5	-0.6	-0.6	-0.7	-0.8	-0.9	-1.0	-0.8	-0.7	-0.5
6	0.3	0.0	-0.4	-0.7	-0.7	-0.6	-0.6	-0.5	-0.4	-0.4	-0.3	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.9	-0.7	-0.6	-0.4
5	0.0	-0.1	-0.3	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.6	-0.7	-0.8	-0.7	-0.6	-0.5	-0.4
4	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.4	-0.3	-0.3	-0.3	-0.2	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.6	-0.5	-0.4
3	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.5	-0.5	-0.5	-0.5	-0.5
2	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.6	-0.3	0.1	0.8	1.5	2.3	3.0	3.1	3.2	3.1	3.0	2.0	1.7	1.4	1.1	0.9	0.8	0.6	0.4	0.3	0.1
10	-0.7	-0.3	0.0	0.5	1.0	1.5	2.0	2.6	3.2	2.8	2.5	2.2	1.8	1.5	1.1	0.9	0.8	0.6	0.4	0.3	0.1
9	-0.6	-0.3	-0.1	0.2	0.6	1.0	1.7	2.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0	0.9	0.7	0.6	0.4	0.2	0.1
8	-0.6	-0.3	-0.1	0.1	0.6	1.0	1.5	1.8	2.0	2.3	2.1	1.9	1.6	1.2	0.9	0.8	0.6	0.5	0.4	0.2	0.1
7	-0.5	-0.3	-0.2	0.0	0.3	0.7	1.0	1.4	1.7	2.1	1.9	1.6	1.4	1.1	0.9	0.8	0.6	0.5	0.4	0.2	0.1
6	-0.4	-0.3	-0.1	0.0	0.1	0.4	0.7	1.0	1.4	1.7	1.5	1.4	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1
5	-0.4	-0.3	-0.2	-0.1	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
4	-0.4	-0.3	-0.3	-0.2	-0.1	0.0	0.2	0.4	0.6	0.8	1.0	0.9	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.1
3	-0.5	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	0.0	0.2	0.4	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.0
2	-0.4	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	-0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-15(a) Wind Speed in Direction of Frontal Motion, W_x

Case 15(O) Series No. 0436,

$\overline{W}_x = 11.4 \text{ m s}^{-1}$, Length of Field L = 7407.6 m, Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.8	1.9	2.0	2.2	2.1	2.1	2.0	1.7	1.3	1.0	1.3	1.7	2.0	2.1	2.1	2.2	2.2	2.1	2.5	2.9	3.2
10	0.8	2.0	2.1	2.2	2.1	2.0	1.8	1.5	1.2	1.0	1.2	1.5	1.8	2.0	2.0	2.1	2.0	2.0	2.3	2.7	3.0
9	0.5	1.3	2.1	2.1	2.0	2.0	1.7	1.5	1.2	0.9	1.2	1.5	1.7	2.0	2.0	2.0	2.0	2.0	2.1	2.5	2.8
8	0.5	1.0	1.5	2.0	1.8	1.6	1.4	1.2	1.0	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.0	2.0	2.1	2.4	2.7
7	0.5	0.9	1.4	1.8	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.9	1.0	1.2	1.4	1.5	1.7	1.8	2.0	2.3	2.5
6	0.2	0.5	0.8	0.7	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.9	1.0	1.2	1.4	1.5	1.7	1.8	2.0	2.2	2.5
5	0.0	0.2	0.3	0.2	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.5	1.6	1.8	2.0	2.2	2.4
4	0.0	0.1	0.2	0.1	0.0	0.1	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.0	2.1
3	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
2	0.4	0.8	1.2	1.6	2.0	1.8	1.7	1.5	1.4	1.2	1.4	1.5	1.6	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9
1	0.5	1.2	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.7	1.8	2.0	2.0	2.0	1.8	1.6	1.5	1.3	1.4	1.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	3.2	3.6	4.0	4.5	5.0	5.5	6.0	8.0	10.0	12.0	14.0	14.0	14.0	14.0	14.0	14.0	13.9	13.9	13.9	13.8	13.8
10	3.0	3.3	3.7	4.0	4.8	5.5	6.2	7.0	8.6	10.3	12.0	13.0	14.0	14.2	14.3	14.5	14.5	14.5	14.5	14.5	14.5
9	2.8	3.2	3.5	3.8	4.2	4.9	5.6	6.3	7.8	9.2	10.7	11.9	13.0	13.5	14.0	14.1	14.2	14.3	14.3	14.4	14.5
8	2.7	3.0	3.4	3.7	4.0	4.7	5.3	6.0	7.2	8.4	9.6	10.8	12.0	12.4	12.8	13.1	13.5	13.6	13.7	13.8	13.9
7	2.5	2.8	3.0	3.3	3.5	3.7	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	12.0	12.1	12.1	12.3	12.6	12.8
6	2.5	2.7	3.0	3.2	3.5	3.7	4.0	4.2	5.1	6.0	6.7	7.3	8.0	8.7	9.3	10.0	10.2	10.4	10.6	10.8	11.0
5	2.4	2.7	2.9	3.1	3.3	3.6	3.8	4.0	4.5	5.1	5.6	6.1	6.7	7.4	8.0	8.3	8.6	8.9	9.3	9.6	9.9
4	2.1	2.1	2.2	2.3	2.3	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.2	6.4	6.6	6.8	7.0	7.2
3	1.9	2.0	2.0	2.1	2.2	2.2	2.4	2.6	2.8	3.2	3.6	4.0	4.1	4.1	4.2	4.5	4.8	5.1	5.4	5.7	6.0
2	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.8	2.5	2.5	2.6	2.7	2.7	2.8	2.8
1	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.2	2.0	2.0	1.9	1.9	1.9	1.9	1.8	1.8

Table 2A-15(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 15(O) Series No. 0436,

$\overline{W}_x = 11.4 \text{ m s}^{-1}$, Length of Field L = 7407.6 m, Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.2	-0.4	-0.6	-0.8	-1.0	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.4	0.6
10	-0.2	-0.4	-0.5	-0.7	-0.8	-1.0	-0.8	-0.6	-0.3	-0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.5
9	-0.2	-0.3	-0.5	-0.6	-0.8	-0.7	-0.5	-0.4	-0.2	-0.1	0.0	0.2	0.3	0.2	0.0	-0.1	-0.1	0.1	0.2	0.3	0.5
8	-0.2	-0.3	-0.4	-0.5	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1	0.1	0.2	0.1	0.0	-0.2	-0.1	0.1	0.3	0.5	0.5
7	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.3	0.2	0.0	-0.2	-0.1	0.1	0.5	0.0	0.1
6	-0.3	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.2	0.4	0.3	0.1	0.0	-0.3	-0.1	0.1	0.4	0.2	0.0
5	-0.2	-0.2	-0.3	-0.3	-0.4	-0.3	-0.2	-0.2	-0.1	0.0	0.2	0.4	0.6	0.3	0.0	-0.4	-0.1	0.2	0.5	0.2	0.0
4	-0.1	-0.2	-0.3	-0.4	-0.5	-0.4	-0.3	-0.2	-0.1	0.0	0.2	0.4	0.6	0.2	-0.1	-0.2	-0.4	-0.1	0.2	0.0	-0.2
3	0.0	-0.1	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	0.1	0.2	0.1	0.0	-0.2	-0.3	-0.1	0.0	0.2	0.0	-0.1
2	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.6	0.7	0.9	1.0	2.0	2.3	2.5	2.8	3.0	3.1	3.2	3.1	3.0	2.5	1.9	1.5	1.1	0.9	0.7	0.5	0.3
10	0.5	0.6	0.7	0.8	1.4	2.0	2.2	2.5	2.7	3.0	3.2	1.0	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.3
9	0.5	0.6	0.8	0.9	1.1	1.4	1.7	2.0	2.3	2.7	3.0	2.7	2.3	2.0	1.5	1.0	0.8	0.7	0.5	0.4	0.2
8	0.5	0.4	0.4	0.6	0.9	1.2	1.4	1.7	2.0	2.2	2.5	2.3	2.0	1.6	1.2	0.8	0.7	0.6	0.4	0.3	0.2
7	0.1	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.5	1.8	2.0	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.3	0.2
6	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.3	1.1	1.0	0.9	0.8	0.6	0.5	0.4	0.2	0.1
5	0.0	-0.3	-0.2	0.0	0.2	0.4	0.7	0.9	1.1	1.1	1.1	1.0	1.0	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1
4	-0.2	-0.4	-0.2	-0.1	0.1	0.2	0.4	0.6	0.7	0.9	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
3	-0.1	-0.3	-0.2	0.0	0.1	0.2	0.3	0.3	0.4	0.5	0.6	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.1	0.1	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-15(c) Vertical Wind Speed, W_Z

Case 15(O) Series No. 0436,

$\overline{W}_x = 11.4 \text{ m s}^{-1}$, Length of Field L = 7407.6 m, Horizontal Increment Δx = 185.19 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.7	-1.9	-2.0	-2.1	-2.1	-2.2	-2.1	-2.0	-2.0	-1.9	-1.9	-1.9	-2.0	-2.0	-2.0	-1.9	-1.8	-1.4	-1.0	-0.5	-0.1
10	-1.7	-1.9	-2.0	-2.1	-2.1	-2.2	-2.2	-2.1	-2.0	-1.9	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.0	-2.0	-1.5	-1.0	-0.5
9	-1.8	-2.0	-2.1	-2.2	-2.2	-2.3	-2.2	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.0	-2.0	-1.5	-1.0	-0.6
8	-1.8	-1.9	-2.0	-2.1	-2.2	-2.3	-2.2	-2.2	-2.1	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.0	-2.0	-1.5	-1.0	-0.6
7	-1.8	-1.9	-2.0	-2.1	-2.3	-2.4	-2.3	-2.3	-2.2	-2.1	-2.1	-2.0	-2.0	-2.0	-2.1	-2.2	-2.1	-2.0	-1.5	-1.0	-0.5
6	-1.9	-2.0	-2.1	-2.2	-2.3	-2.4	-2.5	-2.4	-2.3	-2.2	-2.1	-2.0	-1.9	-1.8	-2.0	-2.1	-1.7	-1.4	-1.0	-0.6	-0.3
5	-2.0	-2.1	-2.2	-2.3	-2.3	-2.4	-2.5	-2.4	-2.3	-2.1	-2.0	-1.9	-1.7	-1.6	-1.8	-2.0	-2.0	-1.5	-1.0	-0.5	0.0
4	-2.1	-2.1	-2.2	-2.2	-2.2	-2.3	-2.3	-2.2	-2.2	-2.1	-2.0	-1.8	-1.5	-1.3	-1.5	-1.7	-1.3	-0.9	-0.4	0.0	0.1
3	-2.2	-2.2	-2.2	-2.2	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.4	0.0	0.1	0.1
2	-2.3	-2.3	-2.2	-2.2	-2.1	-2.0	-2.0	-2.0	-2.1	-2.1	-2.0	-1.7	-1.3	-1.0	-0.7	-0.3	0.0	0.1	0.2	0.0	0.0
1	-2.5	-2.4	-2.3	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-1.5	-1.0	-0.5	0.0	0.1	0.1	0.2	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.1	0.3	1.8	3.2	3.6	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	10.0	10.2	10.3	10.5	10.6	10.8	10.9	11.1
10	-0.5	0.0	2.0	2.7	3.3	4.0	4.5	5.0	5.5	6.0	6.7	7.5	8.2	9.0	9.7	9.9	10.1	10.3	10.4	10.6	10.8
9	-0.6	-0.1	1.0	2.2	2.8	3.5	4.1	4.6	5.1	5.6	6.1	7.0	7.9	8.4	8.9	9.4	9.9	10.0	10.1	10.2	10.3
8	-0.6	-0.1	0.7	1.6	2.2	2.8	3.5	4.1	4.6	5.1	5.5	6.0	7.0	8.0	8.2	8.4	8.6	8.9	9.1	9.3	9.5
7	-0.5	0.0	0.5	1.0	1.6	2.1	2.8	3.4	4.1	4.6	5.1	5.5	6.0	6.5	7.0	7.5	8.0	8.1	8.1	8.2	8.0
6	-0.3	0.1	0.5	0.9	1.4	1.8	2.2	3.0	3.9	4.3	4.7	5.2	5.6	6.0	6.3	6.6	6.8	7.1	7.4	7.7	6.8
5	0.0	0.2	0.3	0.5	1.0	1.5	2.0	2.8	3.5	4.3	4.6	5.0	5.3	5.7	6.0	6.1	6.2	6.3	6.4	6.5	6.0
4	0.1	0.1	0.1	0.0	0.5	1.0	1.5	2.0	2.7	3.4	4.1	4.3	4.5	4.6	4.8	5.0	5.2	5.3	5.5	5.7	5.2
3	0.1	0.0	0.0	0.0	0.4	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.1	4.1	4.2	4.1	4.1	4.0	4.1
2	0.0	0.0	0.0	0.0	0.2	0.3	0.2	0.2	0.9	1.7	1.9	2.0	2.2	2.6	3.1	3.5	3.1	2.8	2.4	2.0	2.5
1	0.0	0.0	0.0	0.0	0.2	0.3	0.2	0.0	0.0	0.4	0.8	1.2	1.6	2.0	2.3	2.7	2.3	2.0	2.0	2.1	2.1

Table 2A-16(a) Wind Speed in Direction of Frontal Motion, W_x

Case 16(P) Series No. 0220,

$\overline{W}_x$ = 6.9 m s^{-1}, Length of Field L = 4444.4 m, Horizontal Increment Δx = 111.11 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	9.0	8.7	8.4	8.1	7.8	7.5	7.2	6.9	6.9	6.9	6.9	7.9	8.9	8.9	8.9	8.9	8.6	8.2	7.9	7.6	7.2
10	9.0	8.7	8.4	8.1	7.8	7.5	7.2	6.9	6.9	6.9	7.4	8.0	8.5	9.0	8.8	8.5	8.3	8.1	7.8	7.6	7.4
9	8.9	8.7	8.4	8.2	7.9	7.7	7.4	7.2	6.9	7.3	7.7	8.1	8.5	8.9	8.7	8.5	8.3	8.1	7.9	7.7	7.5
8	8.6	8.4	8.2	8.0	7.8	7.7	7.5	7.3	7.1	7.2	7.3	7.5	7.6	7.7	7.6	7.6	7.5	7.4	7.3	7.3	7.2
7	8.1	8.0	7.9	7.8	7.7	7.5	7.4	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.3	7.3	7.3	7.4	7.4	7.3
6	7.8	7.7	7.7	7.6	7.5	7.5	7.4	7.3	7.3	7.2	7.1	7.0	7.0	6.9	7.0	7.0	7.1	7.2	7.3	7.3	7.4
5	7.4	7.4	7.3	7.3	7.2	7.2	7.2	7.1	7.1	7.0	7.0	6.9	6.9	6.7	6.8	6.9	6.9	7.0	7.0	7.1	7.1
4	7.3	7.3	7.3	7.2	7.2	7.2	7.1	7.1	7.1	7.1	7.0	7.0	6.6	6.1	6.4	6.7	7.0	7.0	7.0	7.0	7.0
3	7.2	7.2	7.2	7.1	7.1	7.1	7.0	7.0	7.0	7.0	6.9	6.9	6.3	5.7	5.9	6.2	6.4	6.7	6.9	6.9	6.9
2	7.2	7.1	7.0	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.4	5.9	5.4	4.9	5.1	5.3	5.5	5.7	5.9	5.9	6.0
1	7.2	7.1	6.9	6.8	6.7	6.6	6.4	6.3	6.2	6.0	5.9	4.9	4.9	4.8	4.8	4.8	4.8	4.8	4.8	4.9	4.9

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	7.2	6.9	5.9	4.9	3.9	2.9	0.9	0.4	-0.1	-0.6	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.2	-1.2	-1.2	-1.3	-1.3
10	7.4	7.1	6.9	5.9	4.8	3.8	2.8	1.9	1.5	1.2	0.8	0.6	0.4	0.2	0.0	-0.2	-0.3	-0.5	-0.7	-0.9	-1.1
9	7.5	7.3	7.1	6.9	5.9	4.9	3.0	2.5	2.0	1.5	1.0	0.8	0.6	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.2
8	7.2	7.1	7.1	7.0	6.3	5.6	4.9	4.2	3.6	2.9	2.2	1.6	0.9	0.9	0.8	0.8	0.8	0.9	1.0	0.9	0.8
7	7.3	7.2	7.2	7.1	7.0	6.3	5.6	4.9	4.2	3.5	2.8	2.2	1.6	1.6	1.5	1.5	1.4	1.3	1.3	1.2	1.2
6	7.4	7.3	7.2	7.1	7.0	6.9	6.2	5.6	4.9	4.2	3.4	2.7	2.8	2.8	2.9	2.7	2.5	2.3	2.2	2.0	1.8
5	7.1	7.1	7.1	7.1	7.0	7.0	7.0	6.3	5.5	4.8	4.2	3.5	2.9	3.1	3.3	3.1	2.8	2.6	2.5	2.3	2.1
4	7.0	7.1	7.1	7.1	7.1	7.1	6.7	6.3	5.9	5.6	5.2	4.9	4.6	4.2	3.9	3.6	3.2	2.9	2.8	2.7	2.6
3	6.9	6.3	7.0	7.0	7.0	7.0	6.8	6.6	6.4	6.0	5.5	5.1	4.8	4.5	4.2	3.8	3.5	3.2	2.9	2.8	2.7
2	6.0	6.0	6.2	6.5	6.7	6.9	6.7	6.4	6.7	6.9	6.2	5.6	4.9	4.6	4.2	3.9	3.6	3.2	2.9	2.8	2.7
1	4.9	4.9	5.2	5.6	5.9	6.2	6.4	6.7	6.9	6.9	6.9	6.9	5.0	4.7	4.3	4.0	3.6	3.3	2.9	2.8	2.8

Table 2A-16(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 16(P) Series No. 0220,

$\overline{W}_x$ = 6.9 m s^{-1}, Length of Field L = 4444.4 m, Horizontal Increment Δx = 111.11 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-0.9	-0.7	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1	0.2	0.3	0.4	0.6
10	-1.2	-1.2	-1.1	-1.1	-1.1	-1.0	-1.0	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0	0.1	0.2	0.3	0.4
9	-1.1	-1.1	-1.1	-1.0	-1.0	-1.0	-0.8	-0.6	-0.5	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.1	0.2	0.3
8	-1.0	-1.0	-1.1	-1.1	-1.0	-0.8	-0.6	-0.5	-0.3	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	0.0	0.1	0.2	0.4
7	-0.9	-0.9	-1.0	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	0.0	0.1	0.2	0.2
6	-0.6	-0.7	-0.7	-0.8	-0.6	-0.5	-0.3	-0.2	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.1	0.0	0.1	0.1	0.2
5	-0.4	-0.5	-0.5	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1	0.2	0.1	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.1	0.1	0.2
4	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1	0.0	0.1	0.2	0.3	0.2	0.2	0.1	0.0	-0.1	-0.2	-0.1	0.0	0.0	0.1
3	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.0	-0.2	-0.1	-0.1	0.0	0.0	0.0
2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.6	0.7	0.8	0.9	1.0	3.0	3.0	3.0	2.8	2.6	2.4	2.2	2.0	2.0	2.0	2.0	2.0	2.0	1.7	1.5	1.2
10	0.4	0.6	0.7	0.8	0.9	2.0	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.9	1.9	2.0	1.8	1.7	1.5	1.4	1.2
9	0.3	0.5	0.6	0.7	0.8	1.5	2.0	2.0	2.0	2.0	2.1	1.8	1.5	1.6	1.7	1.8	1.6	1.5	1.3	1.2	1.0
8	0.4	0.5	0.6	0.7	0.9	1.0	1.5	1.7	1.8	2.0	2.1	1.6	1.1	1.2	1.3	1.4	1.3	1.2	1.1	1.0	0.7
7	0.2	0.2	0.3	0.5	0.6	0.8	1.0	1.2	1.5	1.8	2.0	1.5	1.0	1.0	1.1	1.1	1.0	1.0	1.0	0.7	0.5
6	0.2	0.2	0.1	0.1	0.0	0.3	0.6	0.9	1.1	1.4	1.7	1.2	0.7	0.9	1.0	0.9	0.9	0.9	0.8	0.4	0.1
5	0.2	0.2	0.1	0.1	0.0	0.2	0.5	0.7	1.0	1.0	1.1	1.0	0.9	0.9	0.8	0.7	0.5	0.4	0.3	0.1	0.0
4	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.7	0.9	1.1	0.9	0.7	0.6	0.4	0.3	0.3	0.2	0.2	0.1	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.8	0.7	0.6	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-16(c) Vertical Wind Speed, W_z

Case 16(P) Series No. 0220,

$\overline{W}_x = 6.9 \text{ m s}^{-1}$, Length of Field L = 4444.4 m, Horizontal Increment Δx = 111.11 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.6	-0.8	-0.9	-1.1	-1.3	-1.5	-1.6	-1.8	-2.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.3	-2.6	-1.9	-1.5
10	-0.7	-0.8	-1.0	-1.1	-1.3	-1.4	-1.6	-1.7	-1.9	-2.0	-2.4	-2.8	-3.2	-3.6	-4.0	-4.0	-4.0	-3.3	-2.6	-1.9	-1.6
9	-0.6	-0.7	-0.9	-1.0	-1.1	-1.2	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-2.5	-3.0	-3.3	-3.5	-3.1	-2.8	-2.4	-2.0	-1.7
8	-0.6	-0.7	-0.8	-0.9	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-2.3	-2.5	-2.8	-3.0	-2.7	-2.3	-2.0	-2.0
7	-0.5	-0.6	-0.7	-0.9	-1.0	-1.1	-1.2	-1.3	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-2.3	-2.6	-2.9	-2.7	-2.5	-2.3	-2.0
6	-0.5	-0.6	-0.7	-0.8	-0.9	-1.0	-1.1	-1.2	-1.4	-1.5	-1.6	-1.7	-1.8	-1.9	-2.1	-2.3	-2.5	-2.7	-2.6	-2.5	-2.5
5	-0.4	-0.4	-0.5	-0.5	-0.6	-0.6	-0.8	-0.9	-1.1	-1.2	-1.4	-1.5	-1.7	-1.8	-2.0	-2.2	-2.3	-2.5	-2.5	-2.4	-2.4
4	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-0.5	-0.7	-0.8	-1.0	-1.2	-1.4	-1.6	-1.7	-1.9	-2.1	-2.2	-2.3	-2.4	-2.4	-2.3
3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.4	-0.6	-0.7	-0.9	-1.1	-1.2	-1.4	-1.6	-1.8	-1.9	-2.1	-2.2	-2.2	-2.3	-2.2
2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	-0.2	-0.4	-0.6	-0.8	-0.9	-1.1	-1.3	-1.5	-1.7	-1.9	-2.1	-2.2	-2.2	-2.1	-2.1
1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.4	-1.6	-1.8	-2.0	-2.1	-2.2	-2.1	-2.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.5	-1.1	-0.8	-0.4	0.0	2.0	2.5	3.0	3.5	4.0	4.3	4.6	4.9	5.1	5.4	5.7	6.0	6.1	6.2	6.2	6.3
10	-1.6	-1.3	-0.9	-0.6	-0.3	0.0	2.0	2.6	3.3	3.9	4.1	4.2	4.3	4.5	4.4	4.3	5.1	5.9	6.0	6.2	6.3
9	-1.7	-1.6	-1.6	-1.5	-1.5	-0.4	0.6	2.0	2.7	3.4	4.1	4.2	4.2	4.1	4.1	4.0	4.4	4.8	5.3	5.7	6.1
8	-2.0	-2.0	-2.0	-2.0	-2.0	-1.0	-0.1	0.9	1.9	2.9	3.9	4.0	4.1	4.2	4.1	4.0	3.9	4.4	4.9	5.4	5.9
7	-2.0	-1.7	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	1.0	2.0	3.0	4.0	4.0	4.0	4.0	3.8	3.6	4.1	4.6	5.0	5.5
6	-2.5	-2.4	-2.3	-2.2	-2.2	-2.1	-2.0	-1.0	0.0	1.0	2.0	3.0	4.0	3.8	3.5	3.3	3.1	3.5	4.0	4.4	4.8
5	-2.4	-2.3	-2.3	-2.2	-2.2	-2.1	-2.1	-1.4	-0.7	0.0	2.0	2.5	3.1	3.0	3.0	2.9	2.8	3.2	3.6	4.0	4.4
4	-2.3	-2.3	-2.3	-2.2	-2.1	-2.0	-1.8	-1.7	-1.6	-0.4	0.8	2.0	2.3	2.7	2.7	2.6	2.5	2.5	3.1	3.6	4.2
3	-2.2	-2.2	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-1.2	-0.4	0.4	1.2	2.0	2.0	2.0	2.0	2.0	2.7	3.3	4.0
2	-2.1	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.0	-2.0	-1.0	0.0	0.2	0.5	0.7	1.0	1.3	1.5	1.8	2.1	2.3	2.6
1	-2.0	-1.9	-1.9	-1.9	-2.0	-2.0	-2.0	-2.0	-2.0	-1.5	-1.0	-0.5	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.8	2.0

Table 2A-17(a) Wind Speed in Direction of Frontal Motion, W_x

Case 17(Q) Series No. 1837,

$\overline{W}_x = 17.5\ m\ s^{-1}$, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	20.8	21.4	21.5	21.6	21.6	21.7	21.6	21.5	20.8	20.1	19.4	18.8	18.1	17.5	15.5	14.8	14.2	13.5	12.8	12.2	11.5
10	20.8	21.5	21.6	21.6	21.6	21.7	21.6	21.5	20.8	20.2	19.5	18.8	18.2	7.5	7.4	7.2	7.1	6.9	6.8	6.6	6.5
9	20.9	21.5	21.6	21.6	21.7	21.6	21.6	21.5	20.9	20.2	19.6	19.0	18.5	17.9	17.3	16.7	16.1	15.5	14.8	14.0	13.3
8	20.9	21.2	21.4	21.7	21.6	21.5	21.5	21.5	21.0	20.5	19.9	19.4	18.8	18.1	17.5	16.8	16.2	15.5	14.8	14.2	13.5
7	20.6	20.9	21.3	21.6	21.5	21.2	20.8	20.5	20.2	19.8	19.5	19.1	18.7	18.2	17.8	17.4	16.6	15.7	14.9	14.1	13.3
6	20.4	21.0	21.5	21.2	20.9	20.6	20.4	20.1	19.8	19.5	19.2	18.9	18.6	18.4	18.1	17.8	17.5	16.8	16.0	15.3	14.3
5	20.3	20.1	19.9	19.7	19.5	19.5	19.5	19.4	19.4	19.0	18.7	18.4	18.0	17.9	17.8	17.7	17.6	17.5	16.2	14.8	13.5
4	20.0	19.8	19.7	19.5	18.5	17.5	18.0	18.5	18.4	18.3	18.1	18.0	17.9	17.8	17.7	17.6	17.6	17.5	16.3	15.1	13.9
3	19.6	19.7	19.6	19.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.6	17.7	17.5	16.0	14.5	13.0
2	19.8	19.0	18.3	17.5	16.5	15.5	15.7	15.9	16.2	16.4	16.6	16.8	17.1	17.3	17.5	17.6	17.5	17.5	16.2	14.8	13.5
1	19.8	19.6	19.5	17.5	15.5	15.5	15.5	15.5	15.5	15.8	16.1	16.4	16.6	16.9	17.2	17.5	17.5	17.5	15.5	13.5	11.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	11.5	9.5	7.5	6.5	5.5	4.5	3.5	2.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4
10	6.5	6.3	6.2	6.0	5.9	5.8	5.6	4.1	2.5	2.2	1.8	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.3	1.3	1.3
9	13.3	11.5	10.4	9.4	8.4	7.4	6.3	5.3	4.4	3.5	2.9	2.3	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.3
8	13.5	12.5	11.5	10.9	10.2	9.6	7.6	5.5	4.8	4.0	3.3	3.0	2.7	2.4	2.0	1.7	1.4	1.4	1.4	1.3	1.3
7	13.3	12.4	11.6	11.1	10.5	9.9	9.4	7.5	5.6	5.1	4.5	3.9	3.4	2.9	2.4	2.0	1.5	1.5	1.5	1.5	1.4
6	14.3	13.3	12.2	11.2	10.7	10.1	9.6	8.1	6.6	6.2	5.9	5.5	4.8	4.2	3.5	3.1	2.7	2.3	1.9	1.5	1.4
5	13.5	12.8	12.0	11.3	10.5	9.8	9.0	8.3	7.5	7.4	7.4	6.5	5.6	4.8	4.1	3.3	2.5	2.3	2.0	1.8	1.5
4	13.9	12.7	11.5	11.1	10.7	10.2	9.8	9.4	8.9	8.4	8.0	7.5	6.5	5.5	4.4	3.4	3.3	3.2	3.0	2.9	2.8
3	13.0	11.5	10.6	9.7	9.7	9.6	9.6	9.5	9.5	9.4	9.4	8.4	7.5	6.5	5.0	3.5	3.5	3.5	3.4	3.4	3.4
2	13.5	12.2	10.8	9.5	9.8	10.0	10.3	10.2	10.0	9.9	9.8	9.6	9.5	7.5	5.5	4.5	3.5	3.4	3.5	3.5	3.6
1	11.5	10.8	10.1	9.4	9.7	10.1	10.4	10.3	10.1	10.0	9.9	9.8	9.6	9.5	5.5	4.8	4.2	3.5	3.6	3.6	3.7

Table 2A-17(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 17(Q) Series No. 1837,

$\overline{W}_x = 17.5\ m\ s^{-1}$, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.2	-0.1	-0.1	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.3	0.0	0.0	0.5	1.0	1.1	1.3	1.4
10	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.4	0.2	0.0	0.0	0.3	0.7	1.1	1.1	1.1
9	-0.2	-0.1	0.0	0.1	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.5	0.0	-0.1	0.0	0.1	0.6	1.0	1.0	1.1
8	-0.2	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	0.0	0.1	-0.1	-0.3	-0.1	0.1	0.2	0.4	0.5	0.6
7	-0.2	0.0	0.1	0.1	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.1	-0.1	0.0	-0.2	-0.5	-0.2	0.0	0.1	0.2	0.4	0.5
6	-0.3	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	0.0	-0.2	-0.5	-0.3	-0.2	0.0	0.1	0.2	0.3
5	-0.5	0.0	0.1	0.1	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.4	-0.3	-0.1	-0.2	-0.4	-0.5	-0.3	-0.2	0.0	0.1	0.2
4	-1.0	-0.5	0.0	0.0	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.5	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
3	-1.0	-0.7	-0.3	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.4	-0.4	-0.4	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	0.0
2	-0.5	-0.4	-0.2	-0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	1.4	1.6	1.7	1.9	2.0	2.0	2.1	2.1	2.1	2.0	2.0	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.4	0.2	0.1
10	1.1	1.1	1.1	1.1	1.1	1.0	1.9	1.8	1.8	1.7	1.5	1.4	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.2	0.1
9	1.1	1.1	1.2	1.2	1.3	1.2	1.1	1.0	1.1	1.3	1.4	1.2	1.0	0.9	0.9	0.9	1.0	0.7	0.5	0.2	0.0
8	0.6	0.7	0.9	1.0	1.0	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.1	0.8	0.6	0.3	0.0
7	0.5	0.6	0.7	0.9	1.0	0.9	0.9	0.9	0.9	1.0	1.0	0.9	0.9	0.9	0.8	0.9	1.0	0.5	0.0	0.0	0.0
6	0.3	0.5	0.6	0.7	0.8	0.6	0.4	0.2	0.4	0.5	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.7	0.4	0.2	0.0
5	0.2	0.4	0.5	0.4	0.3	0.2	0.1	0.0	0.2	0.3	0.4	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.2	0.1	0.0
4	0.0	0.2	0.4	0.3	0.1	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0
3	0.0	0.2	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0
2	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-17(c) Vertical Wind Speed, W_z

Case 17(Q) Series No. 1837,

$\overline{W}_x = 17.5 \text{ m s}^{-1}$, Length of Field L = 11428.4 m, Horizontal Increment Δx = 285.71 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	2.0	2.0	2.0	1.7	1.4	1.1	0.8	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.2	0.1	0.0
10	2.0	1.7	1.4	1.1	0.9	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.4	0.3	0.2	0.1
9	2.0	1.7	1.3	1.0	0.7	0.3	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2	0.4	0.5	0.6	0.4
8	2.0	1.3	0.7	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.2	0.3	0.5	0.6	0.8
7	1.7	1.1	0.6	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.8	1.0
6	1.7	1.1	0.6	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.5	0.7	1.0	1.2
5	2.0	1.7	1.3	1.0	0.7	0.3	0.0	0.0	0.0	0.3	0.6	0.9	0.4	0.0	0.0	0.3	0.6	0.9	1.3	1.6	1.9
4	2.2	2.0	1.7	1.3	1.0	0.7	0.5	0.7	0.9	1.1	1.3	1.5	1.0	0.6	0.8	1.0	1.2	1.5	1.7	1.9	2.1
3	2.4	2.2	2.0	2.0	2.0	1.8	1.5	1.8	2.0	2.0	2.0	2.0	2.0	1.6	1.2	1.5	1.8	1.9	2.0	2.0	2.1
2	2.7	2.5	2.2	2.0	2.1	2.0	2.0	2.4	2.8	3.2	3.2	3.1	2.5	2.0	1.4	2.0	2.0	1.9	1.9	2.0	2.1
1	3.1	3.0	2.8	2.7	2.6	2.4	2.3	3.2	4.0	4.0	4.0	4.0	4.0	3.1	2.2	2.2	2.1	2.0	2.0	2.0	2.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	0.0	-0.5	-1.0	-1.5	-2.0	-3.0	-4.0	-5.1	-6.2	-6.7	-7.1	-7.6	-8.0	-8.3	-8.5	-8.7	-9.0	-9.3	-9.5	-9.8	-10.0
10	0.1	0.0	-0.5	-1.0	-1.5	-2.0	-3.3	-4.7	-6.0	-6.4	-6.8	-7.3	-7.7	-8.1	-8.4	-8.7	-9.0	-9.3	-9.6	-9.9	-10.0
9	0.4	0.3	0.2	0.0	-0.9	-1.9	-2.8	-4.1	-5.3	-5.6	-5.9	-6.2	-6.8	-7.5	-8.1	-8.5	-8.9	-9.2	-9.6	-10.0	-10.1
8	0.8	0.6	0.4	0.3	0.1	-0.1	-2.0	-4.0	-4.4	-4.9	-5.4	-6.0	-6.6	-7.1	-7.7	-8.2	-8.6	-9.1	-9.6	-10.0	-10.1
7	1.0	0.8	0.6	0.4	0.2	0.0	-1.9	-3.8	-3.9	-4.0	-4.7	-5.3	-6.0	-6.5	-7.0	-7.5	-8.0	-8.0	-8.7	-9.4	-10.1
6	1.2	1.0	0.8	0.5	0.3	0.1	-1.5	-3.0	-3.3	-3.6	-3.9	-4.2	-5.1	-6.0	-6.4	-6.8	-7.2	-7.6	-8.0	-8.6	-9.3
5	1.9	1.6	1.2	0.9	0.6	0.2	-0.1	-1.5	-3.0	-3.3	-3.7	-4.0	-4.3	-4.9	-5.4	-6.0	-6.4	-6.8	-7.2	-7.6	-8.0
4	2.1	1.8	1.4	1.0	0.7	0.3	0.0	-1.1	-2.3	-2.2	-2.1	-2.8	-3.6	-4.3	-4.6	-4.8	-5.1	-5.4	-5.7	-5.9	-6.2
3	2.1	2.0	1.6	1.3	0.9	0.6	0.2	-0.9	-2.0	-2.0	-2.0	-2.1	-2.1	-3.0	-4.0	-4.0	-4.1	-4.1	-4.1	-4.6	-5.0
2	2.1	2.0	1.7	1.3	1.0	0.7	0.3	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-2.3	-2.7	-3.0	-3.0	-2.9	-2.9	-2.8	-2.8
1	2.0	2.0	2.0	2.0	1.5	1.0	0.5	0.0	-0.3	-0.7	-1.0	-1.3	-1.7	-2.0	-2.3	-2.5	-2.3	-2.2	-2.0	-2.0	-2.0

Table 2A-18(a) Wind Speed in Direction of Frontal Motion, W_x

Case 18(R) Series No. 1651,

$\overline{W}_x = 25.0 \text{ m s}^{-1}$, Length of Field L = 16000.0 m, Horizontal Increment Δx = 400.0 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	13.7	14.4	15.0	15.0	15.0	15.0	16.0	17.0	17.7	18.3	19.0	19.2	16.1	13.0	12.8	12.6	13.0	14.3	15.6	16.9	15.9
10	13.5	13.7	13.8	14.0	14.4	14.9	15.3	16.6	17.1	17.6	18.0	18.5	15.8	13.0	11.2	12.1	13.0	14.4	15.7	17.1	15.8
9	12.9	13.1	13.0	13.5	14.0	14.5	15.0	16.0	17.0	17.3	17.5	17.8	17.0	13.1	11.4	12.2	12.9	14.3	15.6	17.0	15.7
8	14.8	12.9	12.9	13.0	13.6	14.1	14.6	15.2	15.6	16.1	16.6	17.0	15.1	13.1	12.3	11.5	12.9	13.9	15.0	16.0	14.5
7	12.2	12.4	12.7	12.9	13.1	14.1	15.0	15.2	15.4	15.6	15.8	16.0	14.6	13.1	12.4	11.8	12.9	13.6	14.3	15.0	13.7
6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.4	13.8	14.2	14.6	15.0	14.1	13.1	12.1	12.6	13.0	13.0	13.1	13.1	12.0
5	11.5	11.7	11.8	11.9	12.1	12.3	12.4	12.6	12.7	12.9	13.0	13.0	12.9	12.9	12.8	12.8	12.7	12.7	12.6	11.8	11.0
4	11.3	11.2	11.2	11.1	11.0	11.0	11.0	11.0	11.0	11.0	11.0	12.1	12.2	12.4	12.5	12.1	11.8	11.4	11.0	10.3	9.7
3	10.9	10.6	10.3	9.9	9.6	9.3	9.0	9.0	9.0	9.0	10.0	11.0	11.7	12.3	13.0	12.1	11.1	10.4	9.7	9.0	8.4
2	9.1	9.1	9.1	9.0	9.0	8.0	7.0	6.4	5.8	5.2	7.1	9.0	10.9	11.9	13.0	11.0	9.0	8.0	7.0	7.0	6.9
1	7.0	7.0	7.0	7.0	7.8	6.9	5.9	5.0	6.0	7.0	8.0	9.0	11.0	12.1	13.1	10.1	7.0	6.9	6.8	6.8	6.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	15.9	15.0	14.7	14.3	14.0	13.7	13.3	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	12.9	12.7	12.4	12.2
10	15.8	14.5	14.2	14.0	13.7	13.4	13.2	12.9	12.9	12.9	12.9	12.9	12.9	12.9	13.0	13.0	12.7	12.4	12.2	11.9	11.6
9	15.7	14.3	13.0	13.0	13.0	13.0	13.0	12.0	11.0	11.2	11.4	11.7	11.9	12.1	12.4	12.6	12.8	12.5	12.2	11.8	11.5
8	14.5	13.0	12.0	11.9	11.9	11.9	11.8	11.3	10.8	11.1	11.3	11.3	11.2	11.2	11.1	11.1	11.1	11.2	11.2	11.2	11.2
7	13.7	12.3	11.0	11.0	10.9	10.9	10.8	10.8	10.7	10.7	10.9	11.1	11.1	11.1	11.0	11.0	11.0	11.1	11.1	11.1	11.0
6	12.0	10.9	10.6	10.3	10.0	10.1	10.1	10.2	10.3	10.4	10.4	10.5	10.6	10.6	10.7	10.8	10.8	10.9	10.9	11.0	10.5
5	11.0	10.0	9.0	9.0	9.1	9.1	9.3	9.4	9.6	9.8	10.0	10.1	10.3	10.3	10.2	10.2	10.1	10.1	10.0	9.9	9.9
4	9.7	9.0	8.6	8.1	8.3	8.6	8.8	9.1	9.3	9.3	9.2	9.2	9.2	9.1	9.1	9.0	9.0	9.0	8.9	8.9	8.9
3	8.4	7.7	7.1	7.6	8.1	8.5	9.0	9.5	9.4	9.3	9.2	9.1	9.0	9.3	9.6	9.2	8.7	8.3	7.8	7.4	7.0
2	6.9	6.8	6.8	7.2	7.6	8.0	7.8	7.6	7.4	7.2	7.0	7.6	8.3	8.9	9.5	8.7	7.8	7.0	6.3	5.7	5.0
1	6.7	6.6	6.8	7.0	7.2	7.3	7.2	7.1	7.0	7.0	7.0	7.0	7.0	7.0	9.0	9.1	8.1	7.0	6.3	5.7	5.0

Table 2A-18(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 18(R) Series No. 1651,

$\overline{W}_x = 25.0\ \mathrm{m\ s^{-1}}$, Length of Field L = 16000.0 m, Horizontal Increment Δx = 400.0 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.9	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	-1.0	-1.0
10	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.2	0.1	0.1	0.0	0.0	-1.0	-1.0
9	-1.0	0.0	-0.1	-0.1	-0.2	-0.1	0.0	0.0	0.1	0.2	0.1	0.0	0.1	0.3	0.4	0.3	0.1	0.0	0.0	-1.0	-1.0
8	-1.0	-0.8	-0.6	-0.5	-0.3	-0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.6	0.5	0.5	0.0	0.0	-1.0	-1.0
7	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	-0.1	-0.1	0.0	0.2	0.4	0.6	0.8	1.0	1.0	1.0	1.0	0.0	0.0	-0.8	-0.4
6	-1.0	-0.6	-0.2	-0.1	-0.1	0.0	-0.1	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	1.1	1.0	1.0	0.0	0.0	-0.3	-0.7
5	-1.0	-0.6	-0.1	-0.1	0.0	0.0	-0.1	-0.2	-0.1	0.0	0.2	0.5	0.7	1.0	1.1	1.0	0.9	0.0	0.0	-0.5	-0.2
4	-0.5	-0.2	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	0.0	0.2	0.4	0.6	0.8	1.0	0.7	0.3	0.0	0.0	-0.2	-0.3
3	0.0	-0.3	-0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.1	0.3	0.4	0.6	0.7	0.5	0.2	0.0	-0.1	-0.1	-0.2
2	0.0	0.0	0.1	0.1	0.1	0.0	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	-0.1	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.0	0.0	0.1	0.2	0.4	0.5	0.6	0.7	0.9	1.0	1.1	1.4	1.7	2.0	2.1	2.0	2.0	1.0	0.8	0.6	0.4
10	-1.0	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.8	0.9	1.0	1.3	1.5	1.8	2.1	1.7	1.2	0.8	0.7	0.5	0.4
9	-1.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.1	1.4	1.6	1.9	1.5	1.0	0.9	0.7	0.6	0.4
8	-1.0	0.0	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.7	0.8	0.9	1.0	1.3	1.1	1.0	0.8	0.6	0.5	0.3
7	-0.4	0.0	0.1	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	0.7	0.3	0.0	0.0	0.0
6	-0.7	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.5	0.3	0.0	0.0	0.0
5	-0.2	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.7	0.5	0.2	0.0	0.0	0.0
4	-0.3	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.1	0.0	0.0	0.0
3	-0.2	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0
2	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-18(c) Vertical Wind Speed, W_z

Case 18(R) Series No. 1651,

$\overline{W}_x = 25.0\ m\ s^{-1}$, Length of Field L = 16000.0 m, Horizontal Increment Δx = 400.0 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	6.3	6.2	6.1	6.0	5.6	5.1	5.6	6.0	6.0	6.0	5.6	5.2	4.8	4.4	4.0	4.0	4.0	6.0	8.0	8.1	8.1
10	6.2	5.5	4.7	4.0	4.4	4.9	5.3	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2	4.0	5.0	6.0	8.0	8.2	8.1
9	6.0	5.0	4.0	4.0	4.0	4.0	4.0	4.4	4.8	4.4	4.1	4.2	4.4	4.5	4.7	4.8	5.9	7.0	8.1	8.1	8.1
8	5.2	4.1	3.1	2.0	2.5	3.0	3.5	4.0	4.0	4.0	4.0	4.3	4.7	5.0	5.3	5.7	6.0	7.1	8.1	8.1	8.0
7	4.8	3.4	2.0	2.1	2.2	2.6	3.0	3.4	3.8	3.9	4.0	4.1	4.2	4.7	5.1	5.6	6.0	7.1	8.1	8.0	7.9
6	4.3	2.0	2.0	1.9	2.0	2.3	2.6	2.9	3.1	3.4	3.7	4.0	4.1	4.2	4.8	5.4	6.0	7.0	8.0	8.0	7.6
5	4.0	3.3	2.6	1.9	2.0	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.0	4.0	4.0	5.0	6.0	6.6	7.1	6.7	6.4
4	3.0	2.6	2.2	1.8	1.9	1.9	2.0	2.0	2.7	3.3	4.0	4.1	4.1	4.1	4.0	4.7	5.3	6.0	6.0	6.0	5.6
3	2.0	1.9	1.9	1.8	1.9	1.9	2.0	2.0	3.0	4.0	4.1	4.1	4.2	4.2	4.2	4.2	4.5	4.9	5.2	4.9	4.6
2	1.6	1.7	1.7	1.8	1.9	1.9	2.0	3.0	3.9	4.0	4.1	4.2	4.3	4.2	4.2	4.1	4.1	4.0	4.0	4.0	4.0
1	1.4	1.5	1.6	1.7	1.8	1.9	2.0	3.0	4.0	4.1	4.2	4.2	4.3	4.2	4.2	4.1	4.0	4.0	4.0	4.0	4.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	8.1	8.2	8.2	8.1	8.1	8.0	8.0	7.7	7.3	7.5	7.8	8.0	8.5	9.0	9.5	10.0	10.0	10.1	10.1	10.2	10.2
10	8.1	8.0	8.0	8.0	8.0	7.8	7.5	7.3	7.0	7.2	7.4	7.6	7.8	8.0	8.9	9.9	10.0	10.0	10.1	10.1	10.2
9	8.1	8.0	7.9	7.8	7.5	7.2	6.9	6.6	6.3	6.6	7.0	7.3	7.7	8.0	8.7	9.3	10.0	10.1	10.1	10.1	10.2
8	8.0	7.8	7.5	7.3	7.0	6.8	6.5	6.2	6.0	6.4	6.8	7.1	7.5	7.9	8.4	8.9	9.5	10.0	10.0	10.1	10.1
7	7.9	7.4	6.9	6.4	6.3	6.2	6.1	6.0	5.9	6.0	6.1	6.6	7.1	7.5	8.0	8.5	9.1	9.6	10.1	10.1	10.0
6	7.6	7.1	6.7	6.2	6.1	6.1	6.0	5.5	5.0	5.5	6.0	6.3	6.7	7.0	7.3	7.7	8.0	8.6	9.3	9.1	9.0
5	6.4	6.0	5.8	5.5	5.7	5.9	5.4	4.8	4.3	4.8	5.2	5.7	6.1	6.5	6.9	7.2	7.6	8.0	8.0	8.0	8.0
4	5.6	5.1	4.7	4.2	4.2	4.1	4.1	4.0	4.0	4.5	4.9	5.4	5.9	6.2	6.5	6.8	7.2	7.5	7.8	7.5	7.2
3	4.6	4.3	4.0	4.0	4.0	4.2	4.0	4.0	4.0	4.0	4.0	4.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.5
2	4.0	4.0	3.9	3.9	4.0	4.0	4.5	5.0	4.5	4.0	4.0	4.0	4.5	5.0	4.8	4.6	4.3	4.1	3.9	4.9	6.0
1	4.0	4.0	3.9	4.0	4.0	4.7	5.3	6.0	6.0	4.0	4.0	4.0	4.2	4.3	4.5	4.3	4.2	4.0	2.0	3.3	4.6

Table 2A-19(a) Wind Speed in Direction of Frontal Motion, W_x

Case 19(S) Series No. 1904,

$\overline{W}_x$ = 11.0 m s^{-1}, Length of Field L = 7142.8 m, Horizontal Increment Δx = 178.57 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	0.7	0.8	0.9	0.9	1.0	2.0	3.0	4.0	4.9	3.9	2.9	3.6	4.3	5.0	6.0	7.0	8.0	9.0	10.0	11.0	11.1
10	0.7	0.9	1.0	1.7	2.3	3.0	3.7	4.5	5.2	4.6	3.9	4.9	6.0	7.0	8.0	9.0	10.0	11.0	11.9	11.8	11.7
9	1.0	1.7	2.3	3.0	4.0	5.0	6.0	7.0	6.3	5.7	5.0	6.0	7.0	8.0	9.0	10.0	11.0	13.0	13.0	13.0	13.0
8	3.0	3.5	4.0	4.5	5.0	6.0	7.1	8.1	7.7	7.4	7.0	7.7	8.5	9.2	10.2	11.1	12.1	13.1	13.1	13.0	13.0
7	5.0	5.4	5.8	6.2	6.6	7.0	8.0	9.0	9.0	9.1	9.1	9.1	10.1	11.0	11.7	12.3	13.0	13.1	13.1	13.0	12.9
6	6.0	6.5	7.0	7.6	8.3	8.9	9.2	9.5	9.6	10.0	10.3	10.6	10.9	11.3	11.7	12.2	12.6	13.0	12.9	12.9	12.4
5	7.0	7.4	7.8	8.2	8.6	9.0	9.3	9.6	9.9	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.1	11.8	11.4
4	7.1	7.5	7.9	8.2	8.6	9.0	9.3	9.6	9.9	10.1	10.4	10.7	11.0	11.3	11.5	11.8	12.0	11.7	11.3	11.0	10.6
3	7.2	7.2	7.2	7.2	8.1	9.0	9.1	9.1	9.2	9.3	9.9	10.4	11.0	11.2	11.3	11.5	11.3	11.0	10.5	9.9	9.4
2	7.2	7.1	7.0	7.0	7.0	9.0	9.0	9.0	9.0	9.0	9.5	10.0	10.5	11.0	11.1	11.3	10.9	10.6	9.8	9.0	8.3
1	7.2	7.0	7.0	7.0	7.0	7.5	8.0	8.3	8.5	8.7	9.0	9.4	9.8	10.2	10.6	11.0	11.0	10.0	9.0	8.0	7.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	11.1	11.1	11.2	11.2	11.3	11.2	11.1	11.1	11.0	9.5	8.0	6.5	5.0	5.0	5.0	3.0	1.0	0.9	0.9	0.8	0.7
10	11.7	11.6	11.6	11.5	11.4	11.3	11.3	11.2	11.1	11.0	9.6	8.2	7.0	6.7	6.3	4.0	3.0	2.0	1.0	0.9	0.9
9	13.0	12.8	12.6	12.4	12.2	12.0	11.8	11.6	11.4	11.2	11.0	10.0	9.0	7.5	6.0	4.5	3.0	2.5	2.0	1.5	1.0
8	13.0	12.6	12.1	11.7	11.3	11.4	11.6	11.7	11.8	11.5	11.3	11.0	10.0	9.0	7.5	6.0	4.5	3.0	2.7	2.3	2.0
7	12.9	12.4	11.9	11.5	11.0	11.1	11.1	11.1	11.2	11.3	11.3	11.1	11.0	10.0	9.0	7.1	5.2	4.5	3.7	3.0	2.5
6	12.4	11.9	11.5	11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.6	10.2	9.8	9.4	9.0	8.0	7.0	6.0	5.0	3.8	2.7
5	11.4	11.0	10.7	10.3	10.0	10.2	10.3	10.5	10.7	10.8	11.0	10.5	10.0	9.5	9.0	8.3	7.7	7.0	5.7	4.3	3.0
4	10.6	10.1	9.6	9.2	9.2	9.2	9.1	9.1	9.1	9.1	9.1	9.0	9.0	9.0	8.6	8.2	7.8	7.4	7.0	5.3	3.5
3	9.4	8.9	8.4	8.0	8.5	9.0	9.1	9.1	9.2	9.3	9.1	9.0	8.8	8.7	8.5	8.7	9.0	8.0	7.0	5.6	4.1
2	8.3	7.5	6.8	6.0	6.6	7.2	7.8	8.4	9.0	9.2	9.1	9.0	8.7	8.5	8.2	8.6	9.0	8.0	7.0	5.6	4.2
1	7.0	6.0	5.0	4.9	5.7	6.4	7.2	7.8	8.4	9.0	9.0	9.0	8.8	8.5	8.3	8.7	9.0	8.0	7.0	5.7	4.3

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Table 2A-19(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 19(S) Series No. 1904,

$\overline{W}_x = 11.0\ m\ s^{-1}$, Length of Field L = 7142.8 m , Horizontal Increment Δx = 178.57 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-1.3	-1.5	-1.6	-1.8	-2.0	-2.0	-2.0	-1.0	-0.8	-1.4	-2.0	-1.5	-1.0	-1.6	-2.2	-2.1	-2.0	-1.7	-1.3	-1.0	-0.5
10	-1.3	-1.4	-1.6	-1.7	-1.9	-2.0	-1.5	-1.0	-0.8	-1.4	-2.0	-1.5	-1.0	-1.4	-1.7	-2.1	-1.7	-1.4	-1.0	-0.5	0.0
9	-1.2	-1.3	-1.4	-1.5	-1.6	-1.7	-1.4	-1.0	-0.8	-1.2	-1.7	-1.3	-0.9	-1.5	-2.0	-1.6	-1.3	-0.9	-0.6	-0.2	0.1
8	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-0.7	-1.1	-1.5	-1.2	-0.9	-1.2	-1.4	-1.7	-1.0	-0.7	-0.4	-0.1	0.2
7	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.0	-1.0	-0.7	-1.0	-1.3	-1.0	-0.8	-1.0	-1.2	-1.0	-0.8	-0.6	-0.3	-0.1	0.2
6	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1	-0.9	-0.7	-1.0	-1.1	-1.0	-0.8	-1.0	-1.2	-1.0	-0.7	-0.5	-0.2	0.0	0.2
5	-1.0	-1.0	-1.1	-1.1	-1.1	-1.0	-1.0	-0.8	-0.6	-0.8	-1.0	-0.8	-0.6	-0.8	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2
4	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.8	-0.7	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.1
3	-0.5	-0.7	-0.9	-0.9	-0.8	-0.8	-0.7	-0.5	-0.4	-0.3	-0.3	-0.2	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	0.0
2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-0.5	0.0	1.0	1.0	1.0	0.1	-0.9	-1.3	-1.8	-2.2	-1.4	-0.5	0.3	1.2	2.2	3.1	2.8	2.5	2.3	2.0	1.5
10	0.0	0.4	0.8	1.2	0.6	-0.1	-0.6	-1.1	-1.7	-2.2	-1.4	-0.6	0.3	1.1	1.9	3.1	2.8	2.5	2.1	1.8	1.5
9	0.1	0.4	0.7	1.0	0.4	-0.1	-0.6	-1.1	-1.7	-2.2	-1.6	-1.0	0.0	0.8	1.6	2.9	2.6	2.3	2.1	1.8	1.5
8	0.2	0.4	0.7	0.9	0.4	-0.1	-0.5	-1.0	-1.6	-2.2	-1.5	-0.9	-0.2	0.5	1.2	2.0	2.0	2.1	2.1	1.6	1.2
7	0.2	0.4	0.6	0.8	0.2	-0.2	-0.7	-1.1	-1.6	-2.0	-1.4	-0.8	-0.2	0.4	1.0	1.2	1.5	1.8	2.0	1.5	1.0
6	0.2	0.4	0.6	0.4	0.2	-0.2	-0.6	-1.0	-1.4	-1.7	-1.3	-0.9	-0.4	0.0	0.9	1.1	1.4	1.6	1.8	1.4	0.9
5	0.2	0.3	0.5	0.3	0.1	-0.2	-0.6	-0.9	-1.3	-1.6	-1.3	-1.0	-0.5	0.0	0.5	1.0	1.1	1.3	1.4	1.1	0.9
4	0.1	0.2	0.3	0.2	0.1	-0.2	-0.6	-0.9	-1.0	-1.2	-0.9	-0.6	-0.2	0.1	0.3	0.5	0.7	0.9	1.1	0.9	0.8
3	0.0	0.1	0.2	0.1	0.0	-0.2	-0.5	-0.7	-1.0	-0.9	-0.9	-0.4	0.0	0.2	0.3	0.4	0.6	0.7	0.9	0.7	0.6
2	0.0	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.1	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.2	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-19(c) Vertical Wind Speed, W_z

Case 19(S) Series No. 1904,

$\overline{W}_x$ = 11.0 m s^{-1}, Length of Field L = 7142.8 m, Horizontal Increment Δx = 178.57 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-10.0	-10.0	-10.0	-10.0	-10.0	-9.0	-8.0	-8.0	-8.0	-8.0	-9.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
10	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-9.0	-8.0	-8.0	-8.7	-9.3	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-9.5
9	-10.0	-10.0	-10.0	-10.0	-10.1	-10.1	-10.0	-9.1	-8.2	-8.8	-9.4	-10.0	-10.0	-10.1	-10.1	-10.1	-10.1	-10.1	-10.0	-10.0	-9.5
8	-9.5	-9.7	-9.8	-10.0	-10.1	-10.1	-10.1	-10.0	-8.4	-8.9	-9.5	-10.0	-10.1	-10.2	-10.3	-10.2	-10.1	-10.1	-10.0	-9.5	-9.0
7	-9.2	-9.5	-9.7	-10.0	-10.1	-10.2	-10.1	-10.0	-9.3	-8.5	-9.0	-9.5	-10.0	-10.1	-10.1	-10.1	-10.0	-9.5	-9.0	-8.5	-8.0
6	-8.8	-9.2	-9.6	-10.0	-10.0	-10.0	-10.0	-10.0	-9.3	-8.6	-8.9	-9.3	-9.6	-10.0	-9.7	-9.3	-9.0	-8.7	-8.3	-8.0	-7.7
5	-8.5	-8.8	-9.1	-9.4	-9.7	-10.0	-9.6	-9.2	-8.8	-8.4	-8.0	-8.4	-8.8	-9.2	-8.8	-8.4	-8.0	-7.8	-7.7	-7.5	-7.3
4	-8.2	-8.4	-8.5	-8.7	-8.8	-9.0	-8.7	-8.5	-8.3	-8.0	-7.2	-8.0	-8.1	-8.2	-8.1	-8.0	-7.8	-7.6	-7.4	-7.1	-6.9
3	-8.0	-8.0	-7.9	-7.9	-7.9	-7.9	-8.0	-8.0	-8.0	-7.4	-6.8	-7.2	-7.5	-7.9	-7.7	-7.5	-7.4	-7.2	-7.0	-6.8	-6.6
2	-5.0	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9	-6.0	-6.0	-6.0	-6.0	-6.1	-6.1	-6.1	-6.1	-6.0	-6.1	-6.1	-6.2	-6.2	-6.1
1	-5.0	-4.5	-4.0	-4.0	-4.0	-4.0	-4.0	-4.2	-4.3	-4.2	-4.0	-4.0	-4.0	-4.5	-5.0	-5.5	-6.0	-6.1	-6.2	-6.1	-6.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-10.0	-9.5	-9.0	-8.5	-8.0	-7.8	-7.6	-7.7	-7.9	-8.0	-8.0	-8.0	-7.8	-7.7	-7.5	-8.0	-9.0	-10.0	-10.1	-10.1	-10.2
10	-9.5	-9.0	-8.5	-8.0	-7.7	-7.5	-7.2	-7.5	-7.7	-8.0	-8.0	-8.0	-8.0	-7.6	-7.2	-8.0	-8.7	-9.3	-10.0	-10.1	-10.2
9	-9.5	-9.0	-8.5	-8.0	-7.7	-7.5	-7.2	-7.6	-8.0	-8.0	-8.0	-8.0	-8.0	-7.5	-7.0	-7.5	-8.0	-8.7	-9.3	-10.0	-10.1
8	-9.0	-8.5	-8.0	-7.8	-7.5	-7.3	-7.0	-7.5	-8.0	-8.0	-8.0	-8.0	-8.0	-8.0	-6.6	-7.1	-7.5	-8.0	-8.6	-9.2	-9.8
7	-8.0	-7.8	-7.5	-7.3	-7.0	-6.8	-7.1	-7.4	-7.7	-8.0	-8.0	-8.0	-8.0	-8.0	-6.0	-6.5	-7.0	-7.5	-8.0	-8.5	-9.0
6	-7.7	-7.5	-7.2	-7.0	-6.7	-6.9	-7.1	-7.3	-7.6	-7.8	-8.0	-8.0	-8.0	-6.9	-5.9	-5.9	-6.0	-6.0	-7.0	-8.0	-8.5
5	-7.3	-7.2	-7.0	-6.9	-6.7	-6.9	-7.1	-7.3	-7.4	-7.6	-7.8	-8.0	-7.0	-6.0	-5.9	-5.8	-5.9	-5.9	-6.0	-7.2	-8.3
4	-6.9	-6.7	-6.5	-6.6	-6.6	-6.7	-6.7	-6.8	-6.8	-6.9	-6.9	-7.0	-6.5	-6.0	-5.5	-5.0	-5.1	-5.1	-6.0	-6.9	-7.8
3	-6.6	-6.5	-6.3	-6.1	-6.2	-6.2	-6.2	-6.1	-6.1	-6.0	-6.0	-5.9	-5.8	-5.0	-4.0	-4.0	-4.0	-4.0	-5.0	-6.0	-6.5
2	-6.1	-6.1	-6.0	-6.0	-6.1	-6.1	-5.8	-5.4	-5.1	-4.7	-4.3	-4.0	-4.0	-4.0	-3.0	-2.0	-2.8	-3.6	-4.3	-5.1	-5.8
1	-6.0	-6.0	-6.0	-6.0	-6.0	-6.0	-5.3	-4.7	-4.0	-4.0	-4.0	-3.9	-3.9	-4.1	-2.0	-2.0	-2.0	-2.0	-4.0	-4.5	-5.0

Table 2A-20(a) Wind Speed in Direction of Frontal Motion, W_x

Case 20(T) Series No. 0029.

$\overline{W}_x$ = 19.9 m s^{-1}, Length of Field L = 13333.2 m, Horizontal Increment Δx = 333.33 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	9.9	10.9	11.9	12.9	13.9	14.1	14.2	14.3	14.5	14.5	14.5	14.6	14.6	14.6	14.6	15.2	15.8	17.2	18.5	19.9	19.9
10	9.7	10.4	11.3	12.1	12.7	13.3	13.9	14.1	14.4	14.2	14.1	13.9	13.9	13.9	13.9	14.9	15.9	17.9	18.7	19.6	19.9
9	8.9	9.9	10.6	11.4	12.1	12.5	12.8	13.2	13.6	13.6	13.7	13.7	13.7	13.8	13.8	14.9	16.0	17.4	18.8	19.9	19.9
8	8.7	9.3	9.9	10.6	11.2	11.9	12.1	12.2	12.4	12.5	12.7	13.0	13.3	13.5	13.8	15.1	16.4	18.0	18.9	19.9	19.9
7	7.9	8.6	9.2	9.9	10.2	10.5	10.8	11.0	11.3	11.6	11.9	12.4	12.8	13.3	13.8	15.2	16.6	18.0	18.9	19.9	19.9
6	7.4	7.9	8.4	8.9	9.4	9.9	10.2	10.6	10.9	11.2	11.6	11.9	12.6	13.2	13.9	15.3	16.6	18.0	18.5	19.0	19.5
5	6.7	7.1	7.5	7.9	8.4	8.9	9.4	9.9	10.3	10.7	11.2	11.6	12.0	12.9	13.9	15.2	16.6	17.9	18.2	18.6	18.9
4	5.9	6.4	6.9	7.4	7.9	8.3	8.8	9.2	9.7	10.1	10.6	11.1	11.6	12.1	13.3	14.6	15.8	16.9	17.9	18.3	18.7
3	5.8	5.9	6.4	6.9	7.4	7.9	8.3	8.7	9.1	9.5	9.9	10.7	11.4	12.2	12.9	13.7	13.9	15.2	16.4	17.7	17.3
2	5.8	5.8	5.9	5.9	6.3	6.7	6.3	5.9	6.9	7.9	8.4	8.9	9.4	9.9	10.9	11.9	11.9	12.0	13.9	15.9	15.4
1	5.7	5.8	5.8	5.8	5.9	5.9	5.9	5.9	5.9	5.9	7.9	8.4	8.9	9.4	9.9	9.8	9.6	10.8	11.9	13.7	13.1

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	19.9	19.9	19.9	18.9	17.9	16.7	15.5	14.2	13.0	11.8	10.8	9.9	8.9	7.9	6.9	5.9	5.5	5.2	4.8	4.5	4.1
10	19.9	19.9	19.3	18.6	18.0	16.9	15.9	14.6	13.2	11.9	10.9	9.8	8.8	7.8	6.8	5.9	5.5	5.1	4.7	4.3	3.9
9	19.9	19.9	19.1	18.3	17.6	16.8	16.0	14.9	13.9	12.8	11.6	10.5	9.4	8.5	7.5	6.6	5.7	5.1	4.5	3.9	3.9
8	19.9	19.4	18.8	18.3	17.7	17.2	16.1	15.1	14.0	13.0	11.9	10.6	9.3	8.0	7.2	6.4	5.6	4.8	4.0	3.9	3.8
7	19.9	19.4	18.9	18.3	17.8	17.3	16.2	15.1	14.1	13.0	11.9	10.9	9.9	8.9	7.9	6.9	5.9	4.9	4.0	3.9	3.8
6	19.5	19.1	18.6	18.2	17.7	17.3	16.2	15.1	14.1	13.0	11.9	10.8	9.8	8.7	7.7	6.8	5.9	5.2	4.4	3.7	3.7
5	18.9	18.6	18.4	18.1	17.9	16.9	15.9	15.0	14.0	12.9	11.9	10.8	9.8	8.7	7.7	6.8	5.8	5.1	4.5	3.8	3.8
4	18.7	18.3	17.9	17.4	16.9	16.4	15.9	14.9	13.9	12.8	11.7	10.4	9.2	8.3	7.4	6.6	5.7	5.1	4.5	3.9	3.8
3	17.3	16.8	16.4	15.9	15.9	15.9	14.9	13.9	12.9	11.9	10.9	9.9	8.9	7.9	7.2	6.6	5.9	5.2	4.6	3.9	3.8
2	15.4	14.9	14.4	13.9	13.9	13.9	13.9	12.9	11.9	10.9	9.9	8.9	7.9	7.3	6.6	6.0	5.3	4.6	3.9	3.8	3.7
1	13.1	12.5	11.9	11.9	11.9	11.9	11.9	10.9	9.9	9.2	8.6	7.9	7.4	6.9	6.5	6.0	4.9	3.9	3.8	3.8	3.7

Table 2A-20(b) Wind Speed Perpendicular to Frontal Motion, W_y

Case 20(T) Series No. 0029,

$\overline{W}_x = 19.9$ m s^{-1}, Length of Field L = 13333.2 m, Horizontal Increment Δx = 333.33 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-0.6	-1.0	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.5	-2.0	-2.5	-3.0	-3.0	-2.8	-2.0	-1.7
10	-0.5	-0.8	-1.1	-1.1	-1.2	-1.2	-1.2	-1.2	-1.1	-1.1	-1.1	-1.1	-1.1	-1.4	-1.8	-2.1	-2.4	-2.7	-2.3	-1.9	-1.4
9	-0.4	-0.6	-0.9	-1.0	-1.1	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-0.9	-0.9	-1.2	-1.5	-1.7	-2.0	-2.0	-1.9	-1.5	-1.0
8	-0.3	-0.5	-0.6	-0.8	-1.0	-0.9	-0.9	-0.8	-0.9	-0.9	-0.9	-0.8	-0.8	-0.9	-1.0	-1.2	-1.4	-1.6	-1.3	-1.0	-0.9
7	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.6	-0.7	-0.9	-1.0	-1.1	-1.0	-1.0	-0.9	-0.7
6	0.1	0.0	-0.1	-0.2	-0.4	-0.5	-0.5	-0.4	-0.4	-0.3	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-0.8	-0.6	-0.5	-0.4
5	0.1	0.1	0.0	-0.1	-0.2	-0.3	-0.3	-0.2	-0.2	-0.1	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.7	-0.5	-0.4	-0.3
4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.4	-0.3	-0.2
3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-1.7	-1.3	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
10	-1.4	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	-1.0	-0.9	-0.7	-0.6	-0.4	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.1
8	-0.9	-0.7	-0.6	-0.5	-0.4	-0.2	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
7	-0.7	-0.6	-0.4	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1
6	-0.4	-0.2	-0.1	-0.1	-0.2	-0.2	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0
5	-0.3	-0.1	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0
4	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
3	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2A-20(c) Vertical Wind Speed, W_Z

Case 20(T) Series No. 0029,

$\overline{W}_x$ = 19.9 m s^{-1}, Length of Field L = 13333.2 m, Horizontal Increment Δx = 333.33 meters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
11	-14.0	-14.0	-14.0	-14.0	-14.0	-14.0	-13.8	-13.5	-13.3	-13.0	-12.8	-12.5	-12.3	-12.0	-10.2	-8.5	-6.7	-5.8	-4.9	-4.0	-4.2
10	-14.1	-14.1	-14.1	-14.0	-14.0	-14.0	-13.7	-13.3	-13.0	-12.7	-12.3	-12.0	-11.3	-10.7	-10.0	-8.0	-6.7	-5.3	-4.0	-4.0	-4.0
9	-14.2	-14.2	-14.1	-14.1	-14.1	-14.0	-14.0	-13.5	-13.0	-12.5	-12.0	-11.0	-10.0	-9.0	-8.0	-7.0	-6.0	-5.0	-4.0	-3.8	-3.9
8	-14.3	-14.2	-14.2	-14.1	-14.1	-14.0	-13.5	-13.0	-12.5	-12.0	-11.0	-10.0	-9.0	-8.0	-7.0	-6.0	-5.0	-4.0	-3.8	-3.6	-3.7
7	-14.2	-14.1	-14.1	-14.0	-13.6	-13.2	-12.8	-12.4	-12.0	-11.0	-9.9	-8.9	-7.9	-7.0	-6.1	-5.2	-4.2	-3.9	-3.7	-3.4	-3.5
6	-14.2	-13.8	-13.5	-13.1	-12.7	-12.4	-12.0	-11.0	-10.0	-9.1	-8.1	-7.6	-7.0	-6.4	-5.9	-4.9	-4.0	-3.8	-3.7	-3.5	-3.3
5	-14.0	-13.5	-13.0	-12.5	-12.0	-11.3	-10.7	-10.0	-9.3	-8.7	-8.0	-7.3	-6.7	-6.0	-5.3	-4.7	-4.0	-3.8	-3.6	-3.4	-3.2
4	-13.0	-12.4	-11.8	-11.2	-10.6	-10.0	-9.5	-8.9	-8.4	-7.9	-7.2	-6.6	-5.9	-5.3	-4.8	-4.2	-4.0	-3.7	-3.5	-3.2	-3.0
3	-12.0	-11.5	-11.0	-10.5	-10.0	-9.3	-8.7	-8.0	-7.5	-6.9	-6.4	-5.9	-5.4	-4.9	-4.5	-4.0	-3.9	-3.8	-3.6	-3.5	-3.4
2	-11.5	-10.6	-10.1	-9.4	-8.7	-8.0	-7.6	-7.2	-6.7	-6.3	-5.9	-5.0	-4.1	-4.1	-4.0	-3.8	-3.6	-3.5	-3.3	-3.1	-2.9
1	-11.0	-10.5	-10.0	-9.3	-8.5	-7.8	-7.3	-6.9	-6.4	-6.0	-5.0	-4.0	-3.9	-3.9	-3.8	-3.6	-3.4	-3.3	-3.1	-2.9	-2.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
11	-4.2	-4.4	-4.7	-4.9	-5.1	-5.3	-5.6	-5.8	-6.0	-6.5	-7.0	-7.5	-8.0	-9.0	-10.0	-11.0	-12.0	-12.1	-12.1	-12.1	-12.2
10	-4.0	-4.2	-4.4	-4.7	-4.9	-5.1	-5.3	-5.6	-5.8	-6.0	-6.5	-7.0	-7.5	-8.0	-9.0	-10.0	-10.4	-10.8	-11.2	-11.6	-12.0
9	-3.9	-4.0	-4.2	-4.4	-4.6	-4.8	-5.0	-5.2	-5.4	-5.6	-5.8	-6.0	-6.7	-7.3	-8.0	-8.5	-9.0	-9.5	-10.0	-10.5	-11.0
8	-3.7	-3.8	-3.9	-4.0	-4.2	-4.4	-4.7	-4.9	-5.1	-5.3	-5.6	-5.8	-6.0	-6.5	-7.1	-7.6	-8.1	-8.6	-9.1	-9.5	-10.0
7	-3.5	-3.6	-3.8	-3.9	-4.0	-4.2	-4.4	-4.7	-4.9	-5.1	-5.3	-5.6	-5.8	-6.2	-6.5	-6.9	-7.3	-7.6	-8.0	-8.5	-9.0
6	-3.3	-3.5	-3.7	-3.8	-4.0	-4.1	-4.2	-4.4	-4.5	-4.6	-4.9	-5.3	-5.7	-6.0	-6.3	-6.6	-6.9	-7.1	-7.4	-7.7	-8.0
5	-3.2	-3.4	-3.5	-3.7	-3.8	-4.0	-4.0	-4.1	-4.1	-4.1	-4.5	-4.9	-5.2	-5.6	-6.0	-6.0	-6.1	-6.1	-6.4	-6.8	-7.1
4	-3.0	-3.1	-3.2	-3.3	-3.4	-3.5	-3.6	-3.7	-3.8	-3.9	-4.0	-4.2	-4.4	-4.7	-4.9	-5.1	-5.4	-5.7	-5.9	-6.2	-6.5
3	-3.4	-3.3	-3.2	-3.0	-2.9	-2.8	-2.9	-2.9	-3.0	-3.0	-3.1	-4.0	-4.1	-4.3	-4.4	-4.5	-4.8	-5.1	-5.4	-5.7	-6.0
2	-2.9	-2.7	-2.5	-2.4	-2.2	-2.0	-2.2	-2.3	-2.6	-3.0	-3.3	-3.7	-4.0	-4.0	-4.0	-4.1	-4.1	-4.1	-4.4	-4.7	-5.0
1	-2.7	-2.5	-2.4	-2.2	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.5	-3.0	-3.4	-3.9	-3.7	-3.5	-3.6	-3.7	-3.8	-3.9	-4.0

APPENDIX 2B

GRAPHICAL ILLUSTRATION OF THUNDERSTORM WIND SPEED PROFILES

This appendix contains graphical illustrations of the wind speed profiles encountered along flight paths having a 3° glide slope through each of the 20 thunderstorm cases. The position of each flight path relative to the streamlines fixed in the frame of reference moving with the storm is illustrated in each of the figures, and is chosen to terminate in the left-hand corner of each data set. The flight paths are, therefore, essentially arbitrary flight paths which could be encountered during any routine landing through a passing thunderstorm.

The longitudinal, lateral, and vertical wind speeds encountered along the glide slope are shown. The ordinate in the wind speed profiles is height, $\hat{z}$, nondimensionalized with the length, $H = L \tan 3°$, where L is the length of the wind field. Each profile is the wind as seen by an airplane traveling along the flight path drawn across the streamlines as shown in the upper figures. Note that the streamlines plotted are relative to the speed of the front which, for reference purposes, has been indicated on the horizontal wind speed profile with a vertical dashed line. The wind speed profiles are relative to the fixed earth frame of reference.

The purpose of these illustrative profiles is to provide an impression of the diversity and severity of wind shear that can be encountered during a routine approach when a thunderstorm is in the vicinity of the terminal area. The data sets do not necessarily represent a wind field through the center of the storm nor the worst downdraft conditions, but represent storms which may have passed either to one side or the other of the tower from which the data were measured. Therefore, the profiles do not illustrate necessarily the 20 most severe flight paths which would be encountered through the given thunderstorms but rather a collection of wind speed profiles that represent an averaged situation.

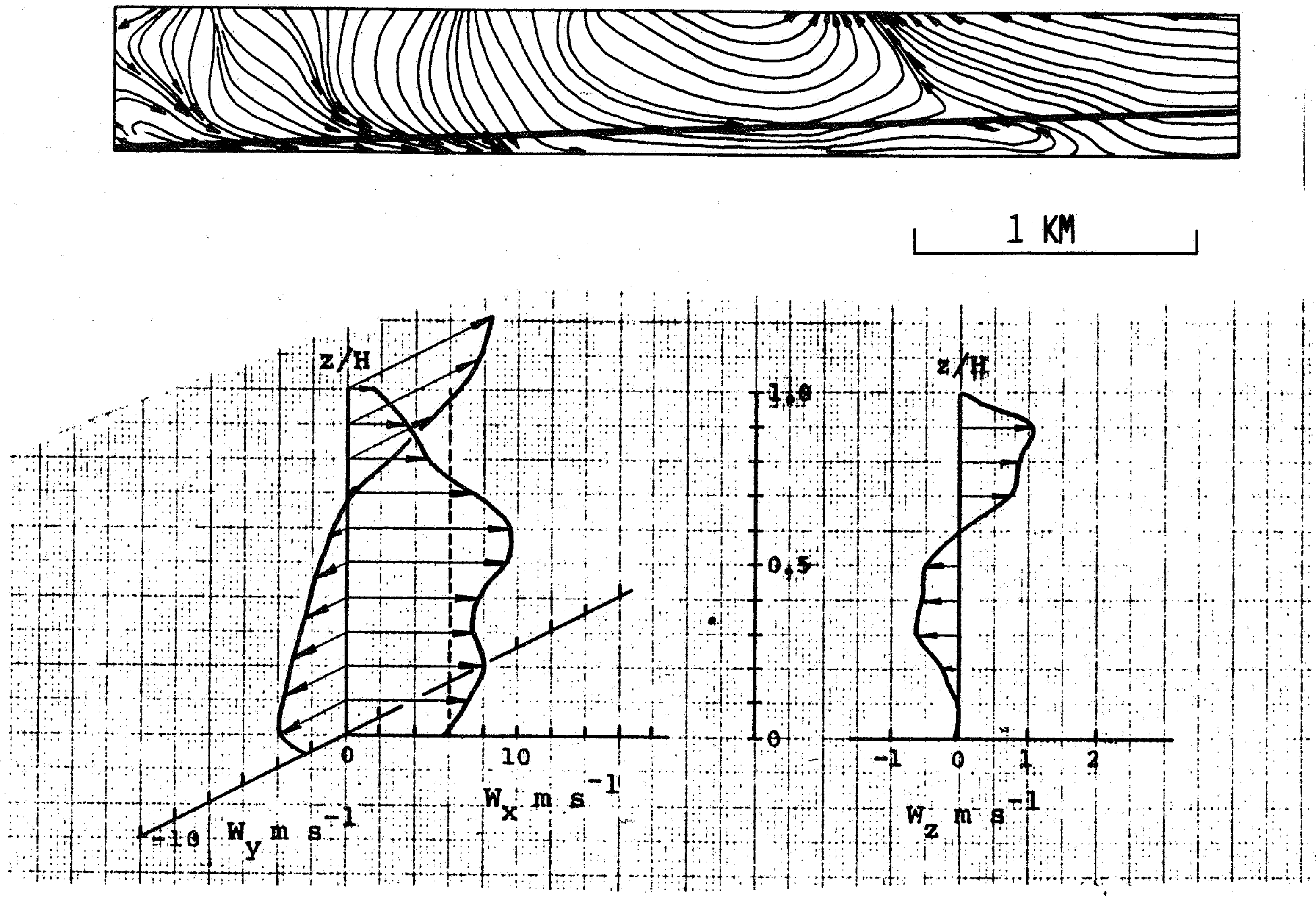

Figure 2B-1 Typical Wind Profiles along a 3° Glide Slope: Case 1(A) Series No. 0446, 14 May 74, $\overline{W}_x = 6.1$ m s^{-1}, H = 4000 tan 3° (m)

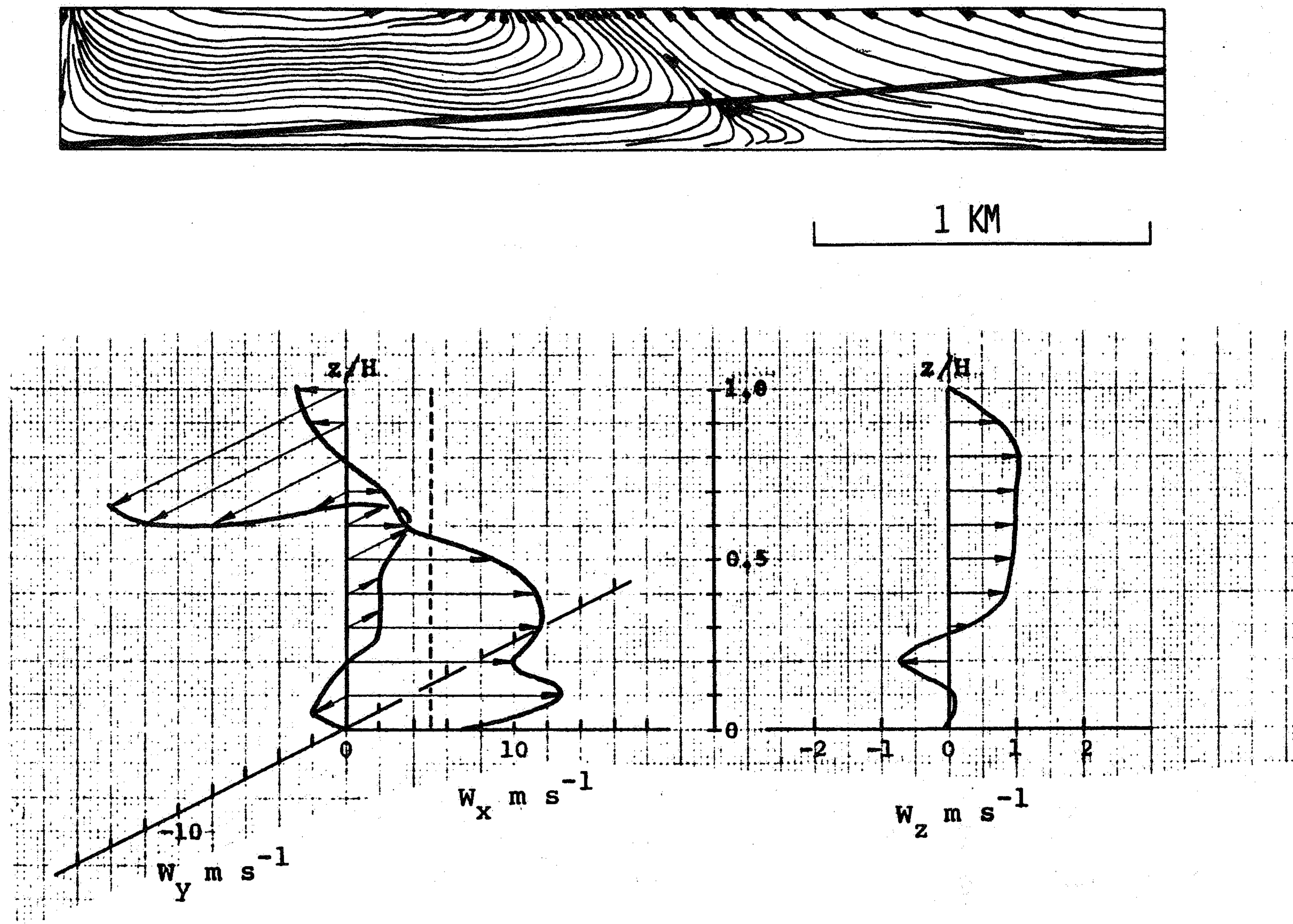

Figure 2B-2 Typical Wind Profiles along a 3° Glide Slope: Case 2(B) Series No. 1314, 2 Jul 72, $\overline{W}_X = 5.0$ m s^{-1}, H = 3279 tan 3° (m)

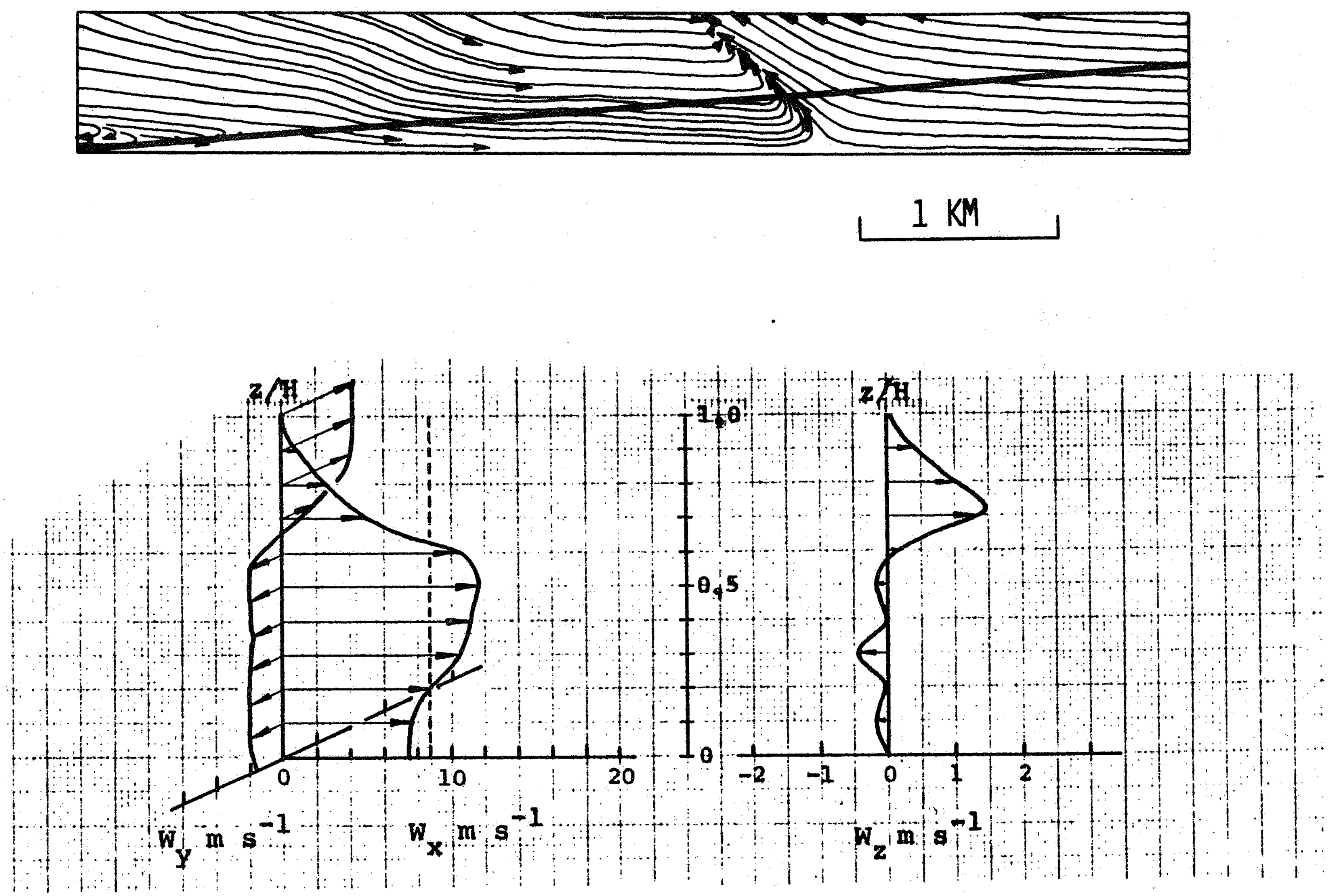

Figure 2B-3 Typical Wind Profiles along a 3° Glide Slope: Case 3(C) Series No. 1731, 6 May 72, $\overline{W}_x = 8.6$ m s^{-1}, H = 5714 tan 3° (m)

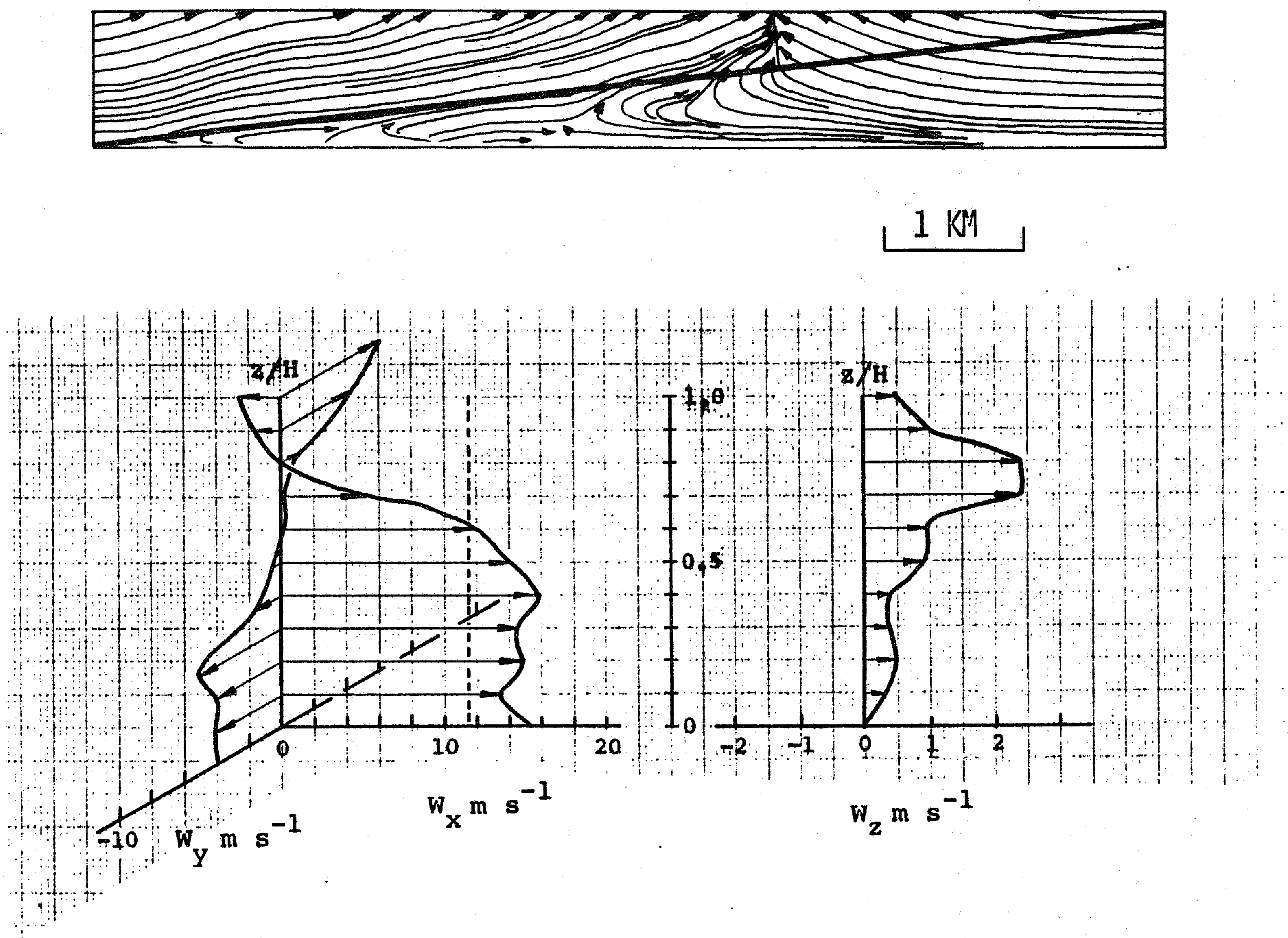

Figure 2B-4 Typical Wind Profiles along a 3° Glide Slope: Case 4(D) Series No. 1459, 27 May 72, $\overline{W}_x$ = 11.6 m s^{-1}, H = 7692 tan 3° (m)

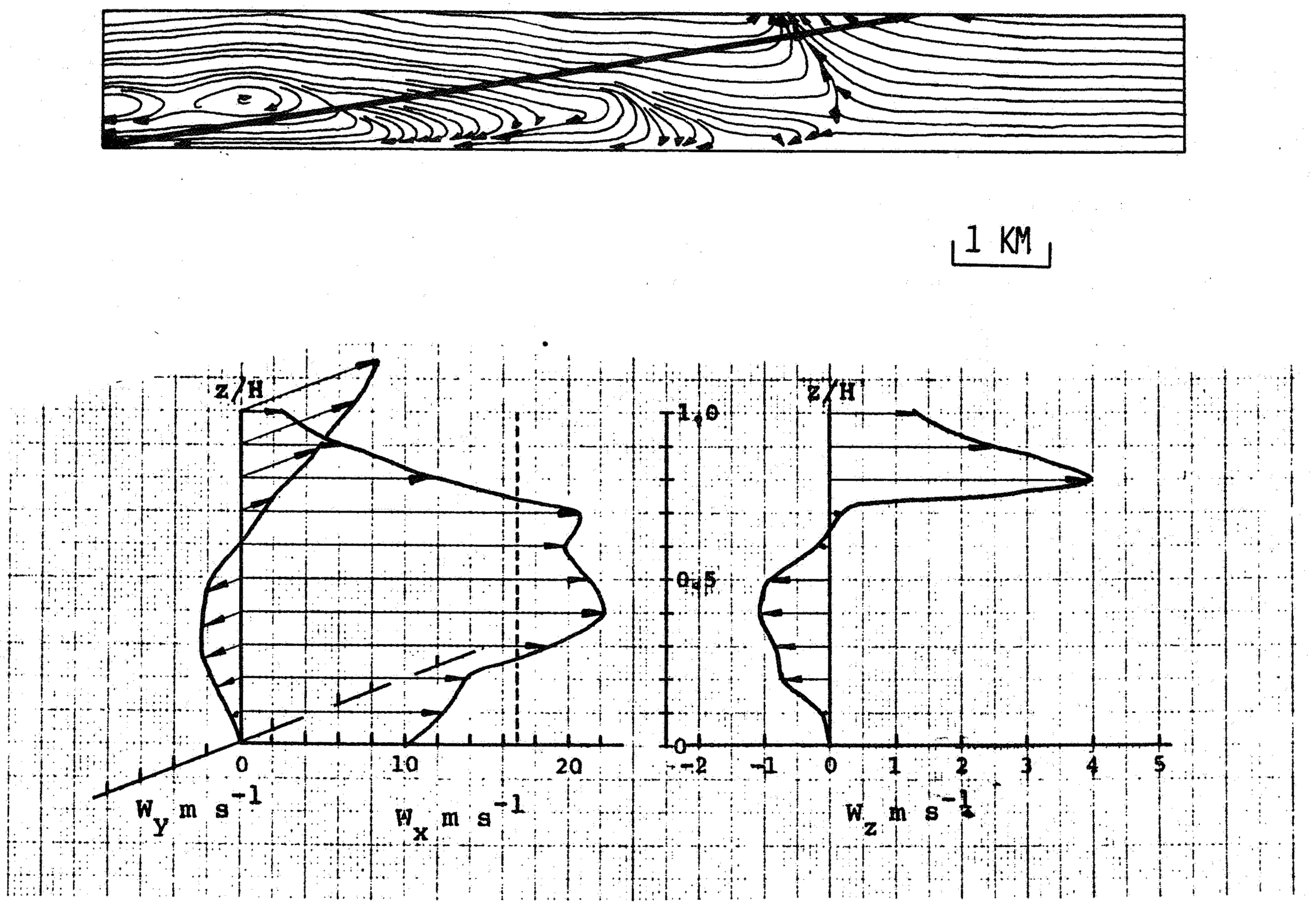

Figure 2B-5 Typical Wind Profiles along a 3° Glide Slope: Case 5(E) Series No. 1924, 31 May 71, $\overline{W}_x = 16.7$ m s^{-1}, H = 11428 tan 3° (m)

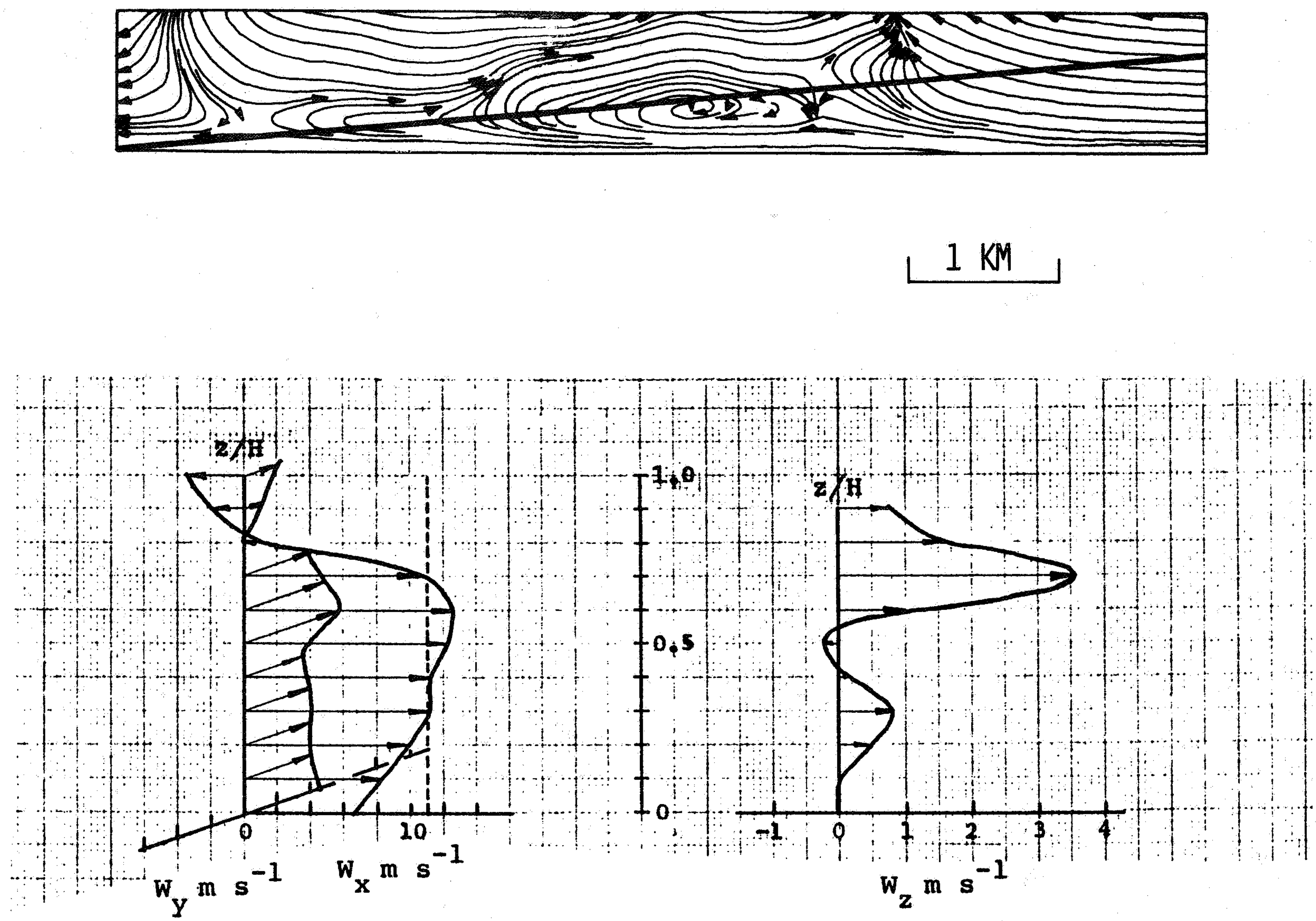

Figure 2B-6 Typical Wind Profiles along a 3° Glide Slope: Case 6(F) Series No. 1933, 27 Jun 72, $\overline{W}_x = 11.0$ m s^{-1}, H = 7273 tan 3° (m)

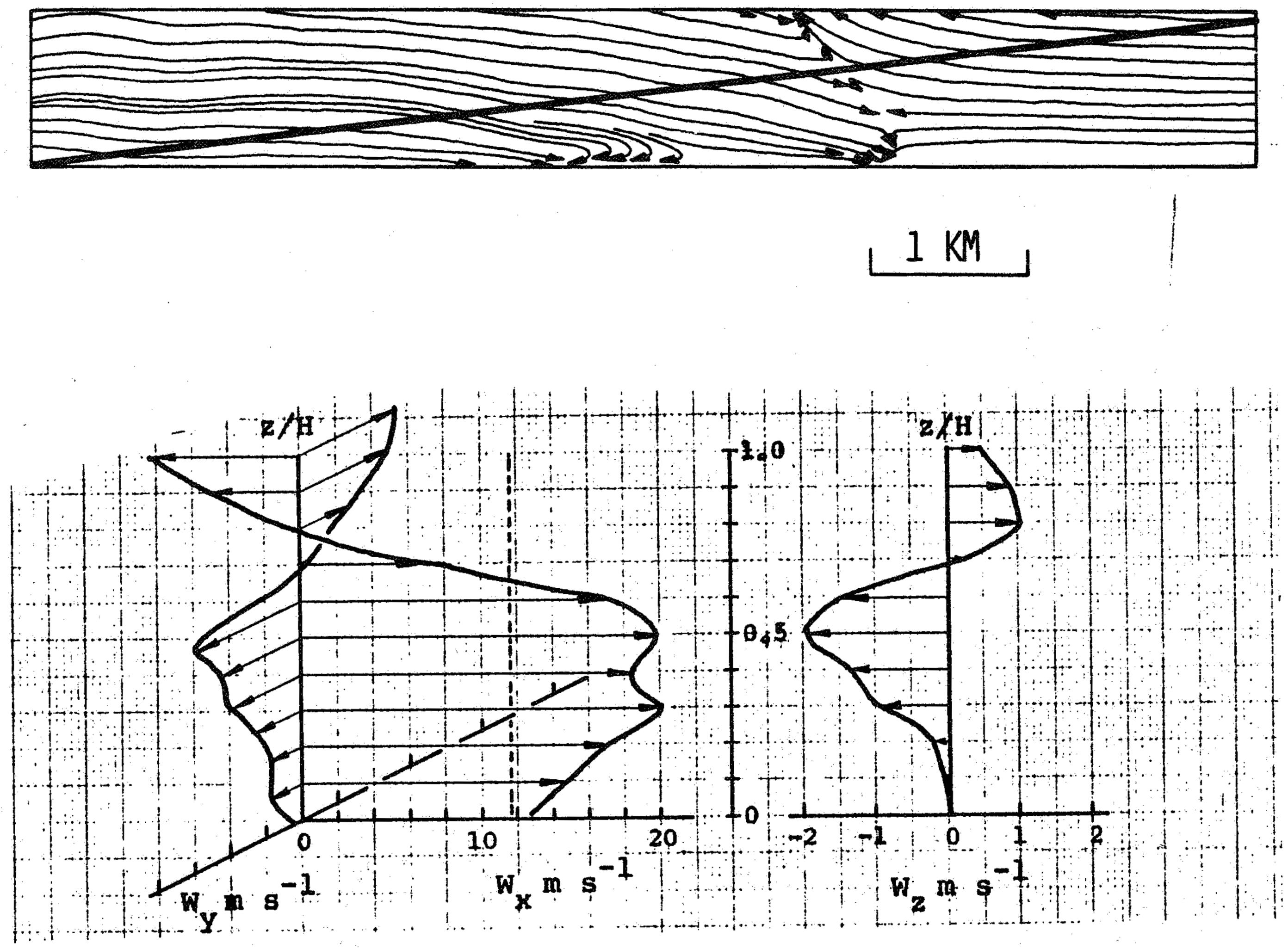

Figure 2B-7 Typical Wind Profiles along a 3° Glide Slope: Case 7(G) Series No. 1942, 7 Jun 71, $\overline{W}_x = 11.8$ m s^{-1}, H = 7843 tan 3° (m)

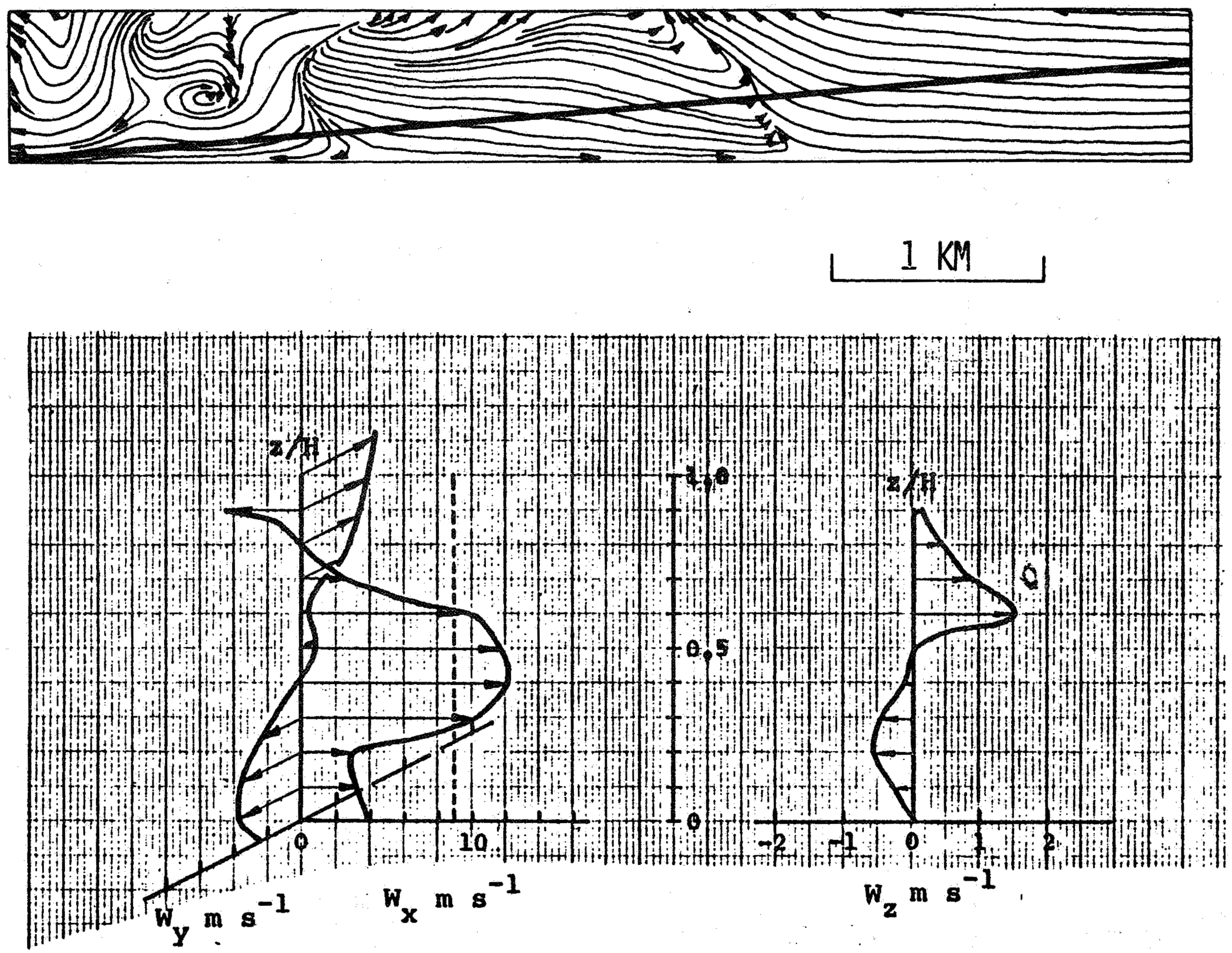

Figure 2B-8 Typical Wind Profiles along a 3° Glide Slope: Case 8(H) Series No. 1712, 23 May 74, $\overline{W}_x = 8.5$ m s^{-1}, H = 5556 tan 3° (m)

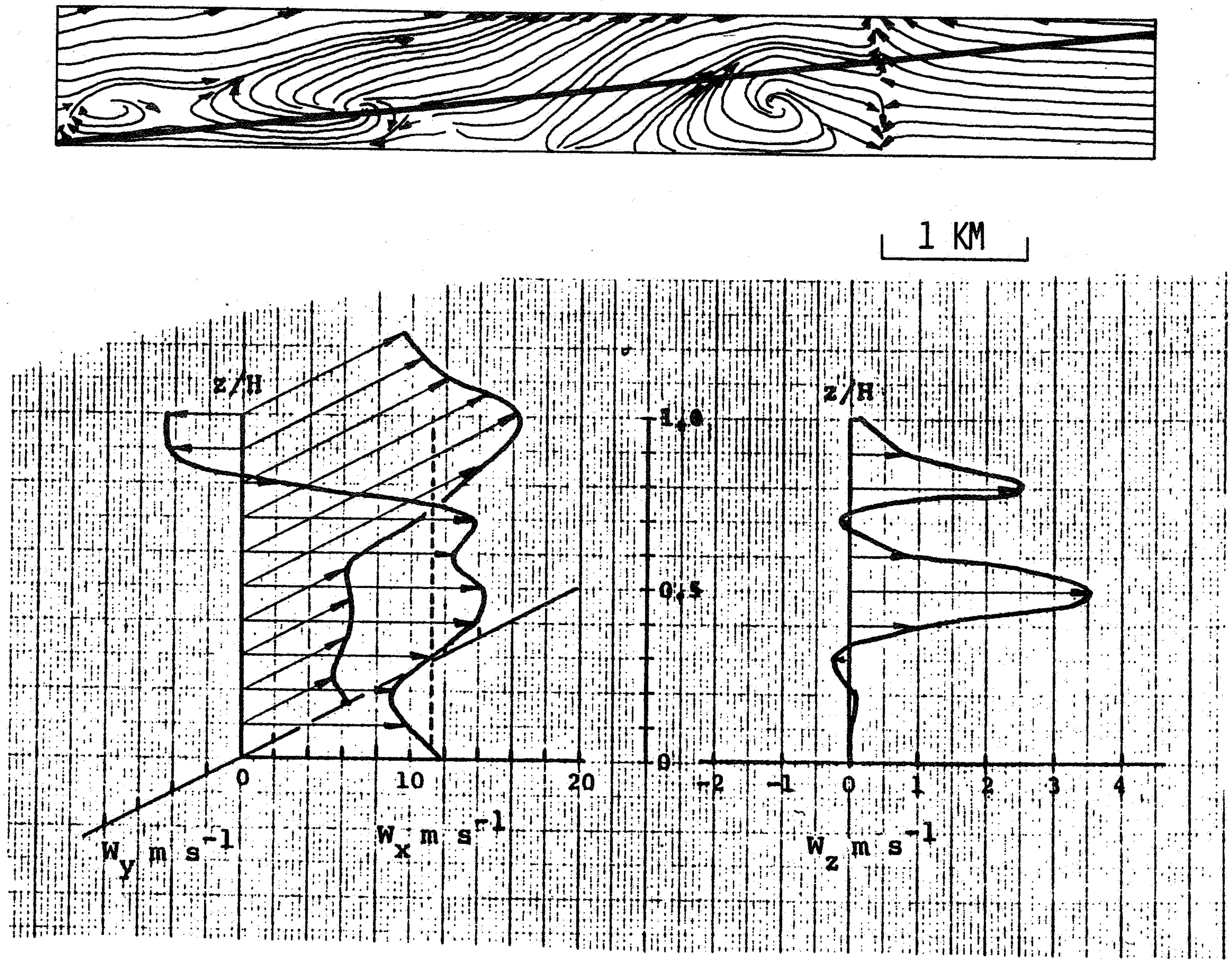

Figure 2B-9 Typical Wind Profiles along a 3° Glide Slope: Case 9(I) Series No. 1507, 16 Jun 73, $\overline{W}_x = 11.5$ m s^{-1}, H = 7408 tan 3° (m)

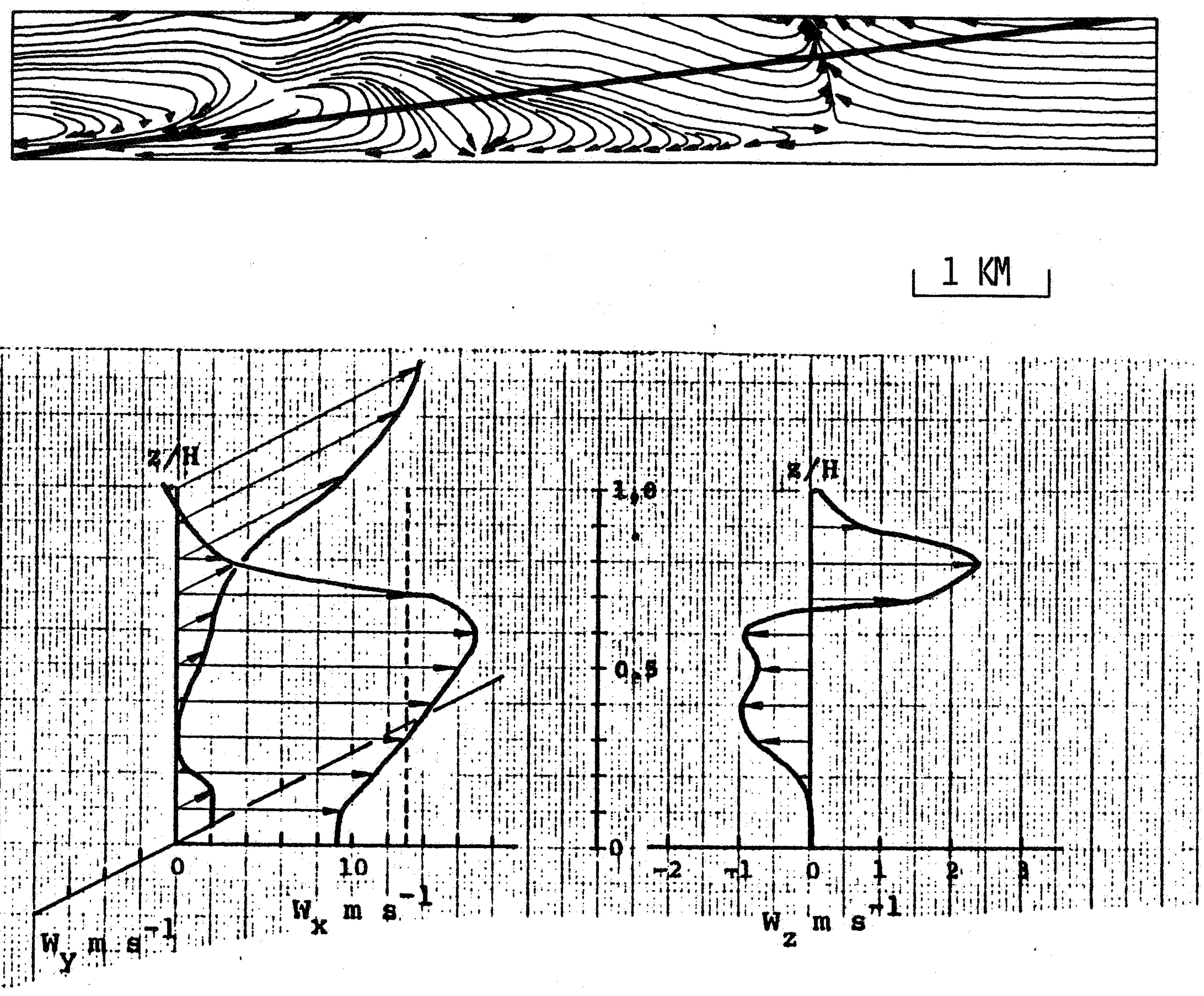

Figure 2B-10 Typical Wind Profiles along a 3° Glide Slope: Case 10(J) Series No. 2206, 10 Jun 71, $\overline{W}_x = 13.1$ m s^{-1}, H = 8511 tan 3° (m)

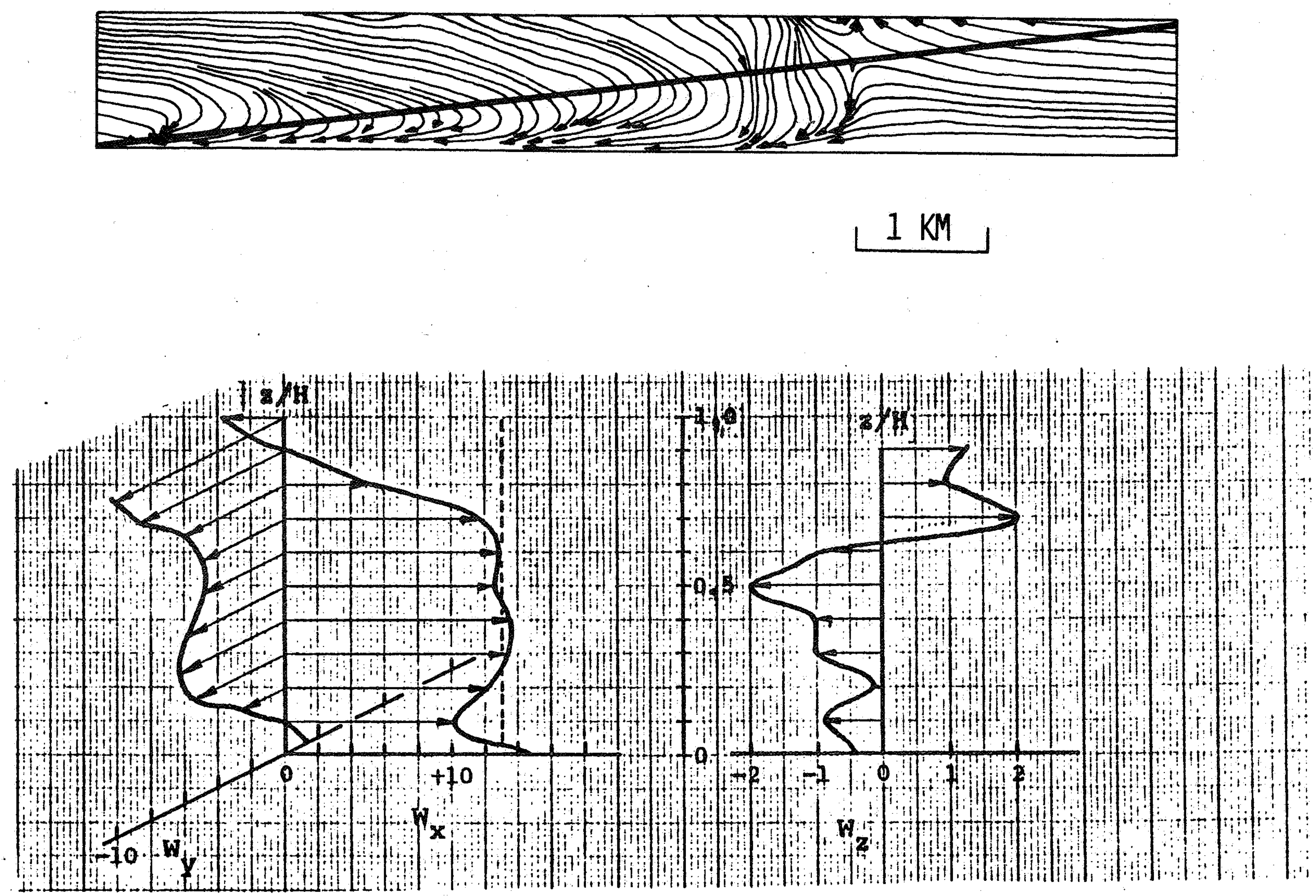

Figure 2B-11 Typical Wind Profiles along a 3° Glide Slope: Case 11(K) Series No. 2118, 2 Jun 71, $\overline{W}_x$ = 12.4 m s^{-1}, H = 8163 tan 3° (m)

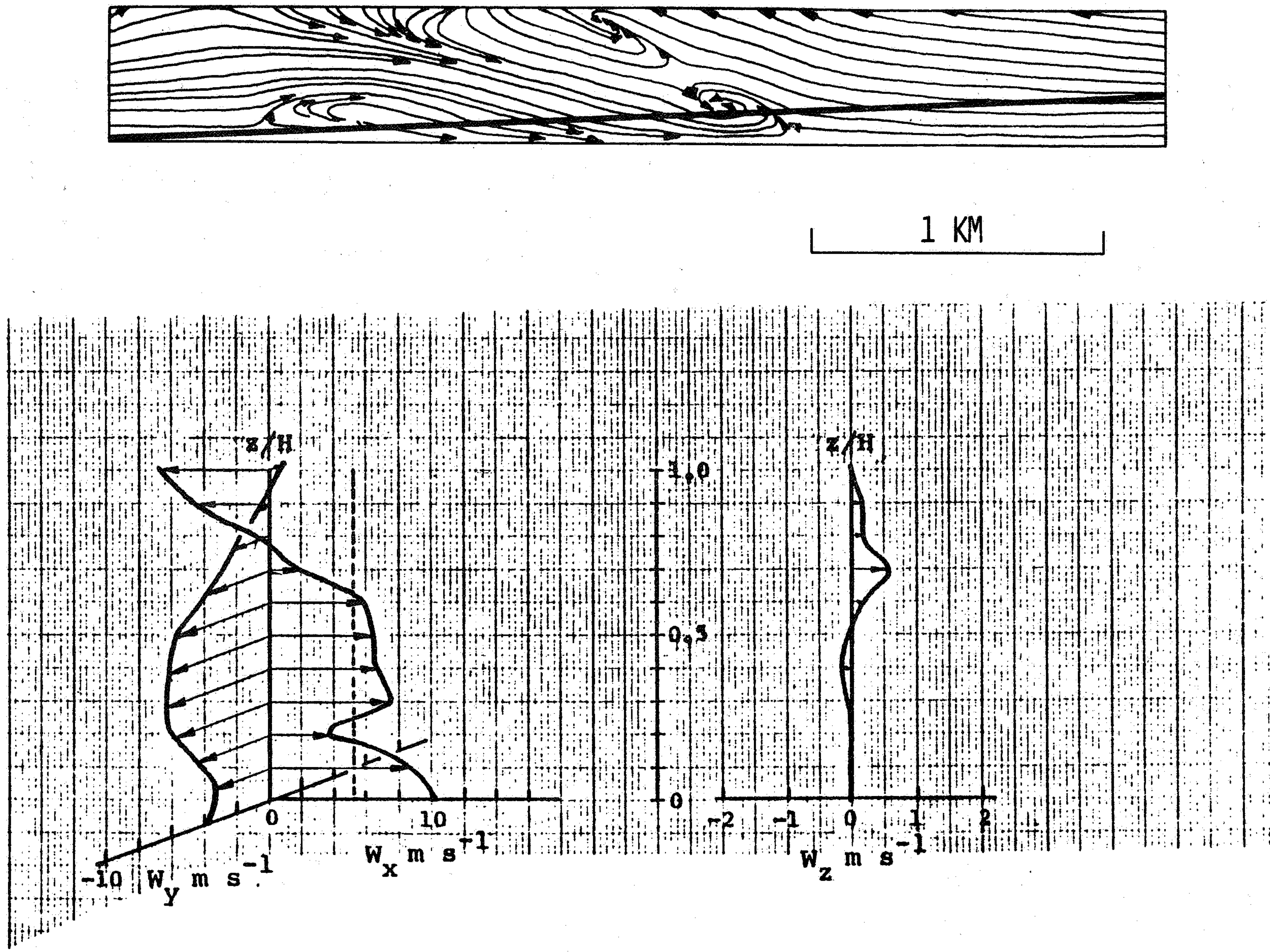

Figure 2B-12 Typical Wind Profiles along a 3° Glide Slope: Case 12(L) Series No. 1759, 4 Jun 73, $\overline{W}_x = 5.5$ m s^{-1}, H = 3636 tan 3° (m)

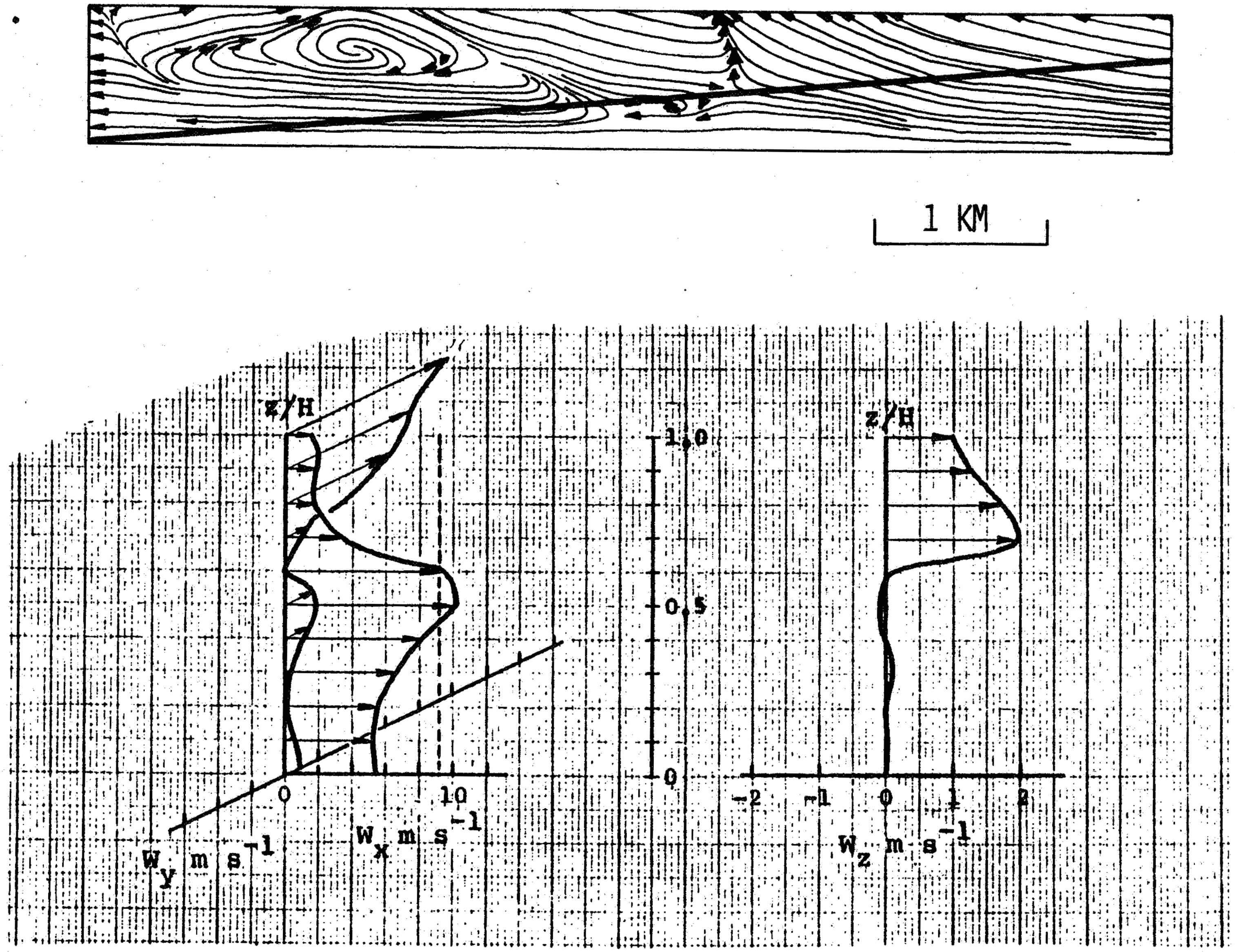

Figure 2B-13 Typical Wind Profiles along a 3° Glide Slope: Case 13(M) Series No. 0211, 14 Jun 72, $\overline{W}_x = 9.6$ m s^{-1}, H = 6349 tan 3° (m)

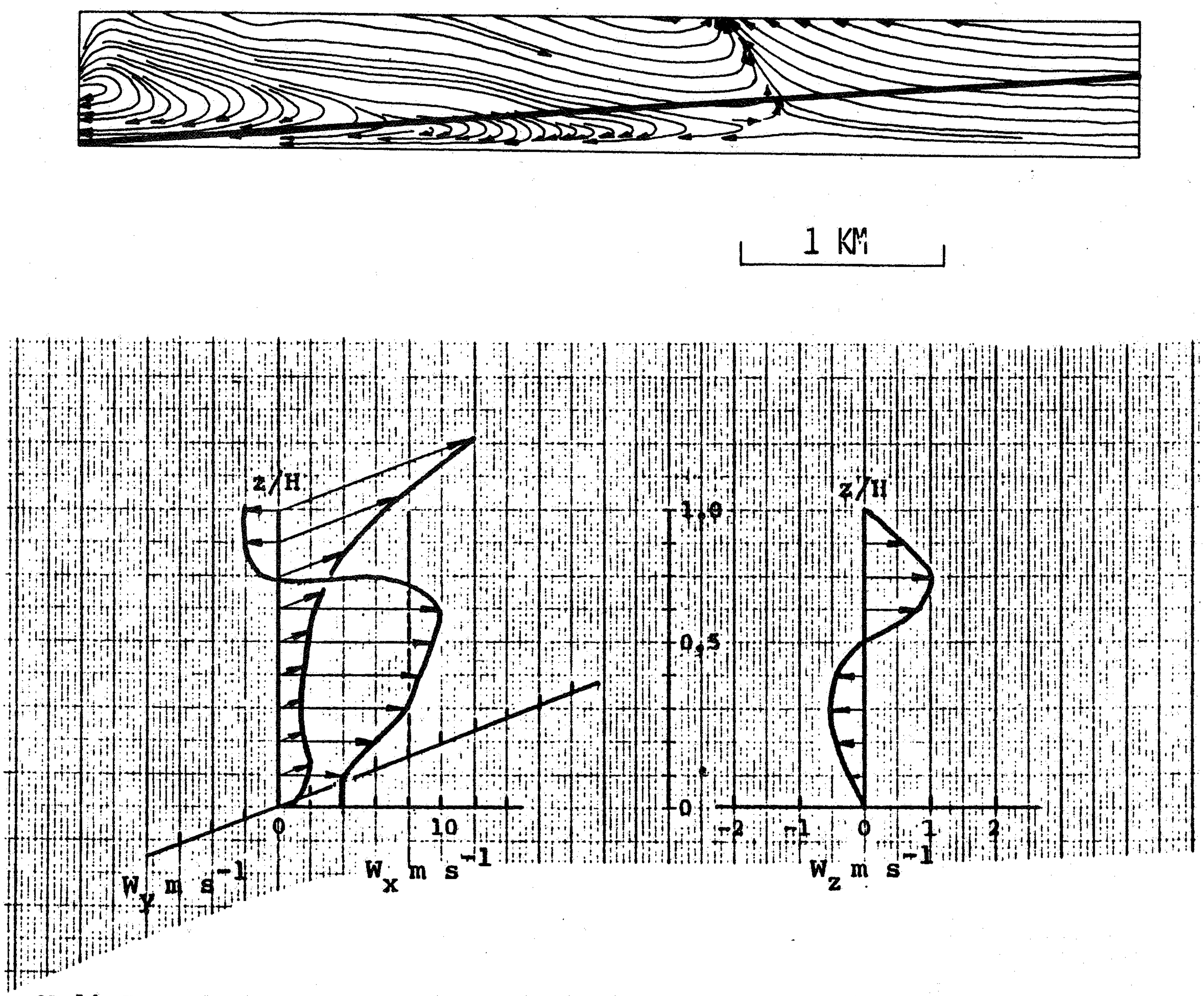

Figure 2B-14 Typical Wind Profiles along a 3° Glide Slope: Case 14(N) Series No. 0109, 12 Jun 71, $\overline{W}_x = 8.0$ m s^{-1}, H = 5128 tan 3° (m)

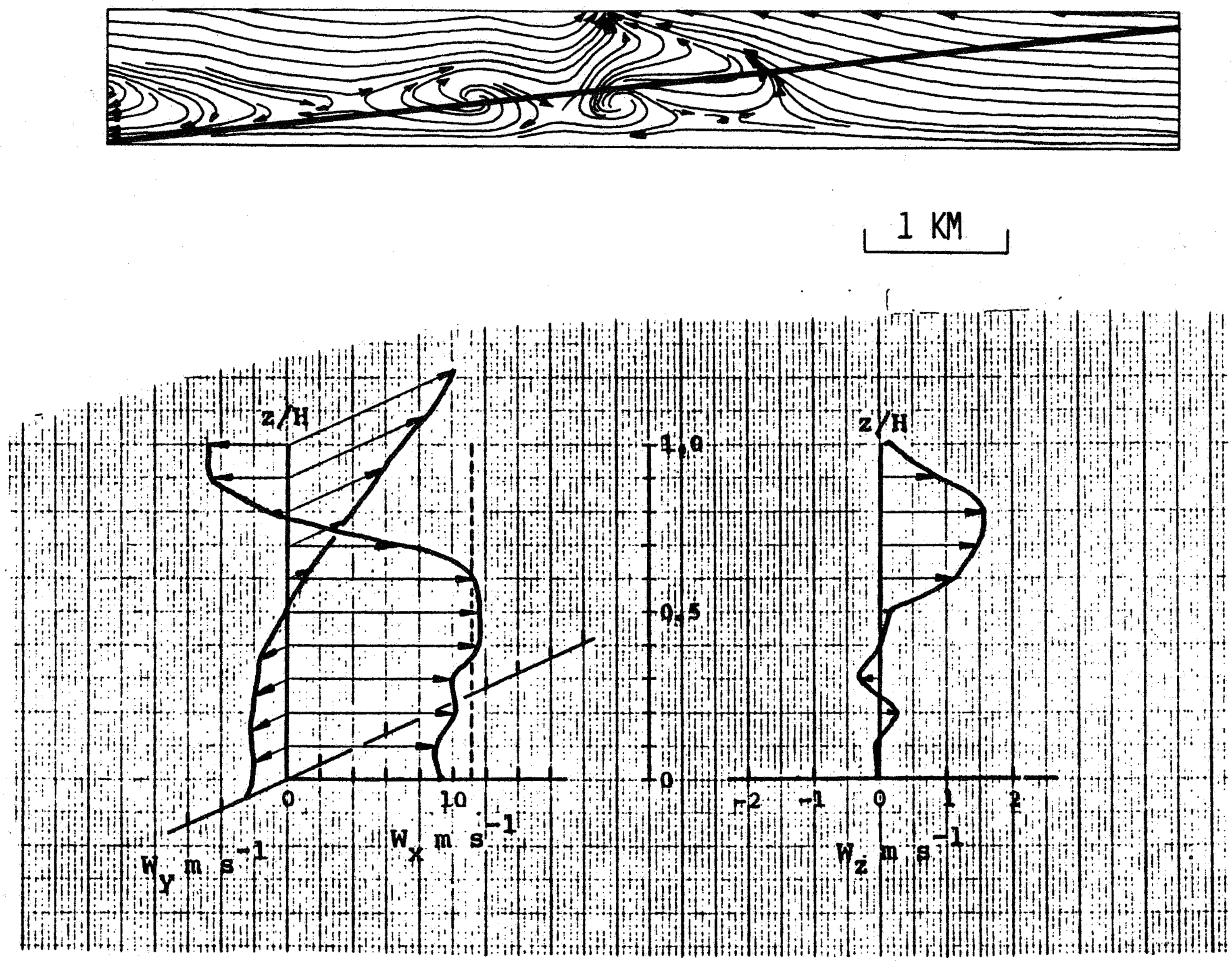

Figure 2B-15 Typical Wind Profiles along a 3° Glide Slope: Case 15(0) Series No. 0436, 23 May 72, $\overline{W}_x = 11.4$ m s^{-1}, H = 7408 tan 3° (m)

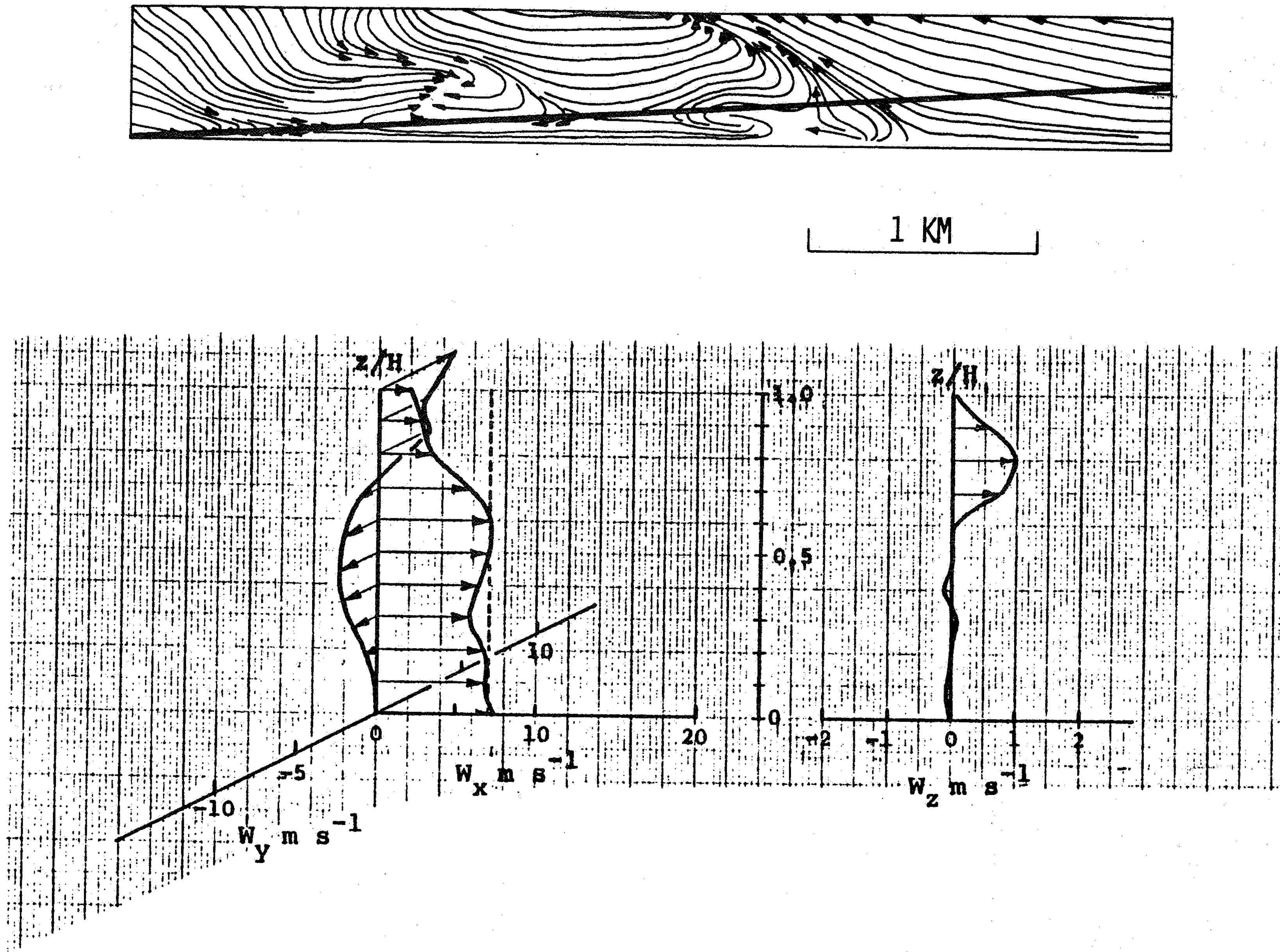

Figure 2B-16 Typical Wind Profiles along a 3° Glide Slope: Case 16(P) Series No. 0020, 12 May 72, $\overline{W}_x = 6.9$ m s^{-1}, H = 4444 tan 3° (m)

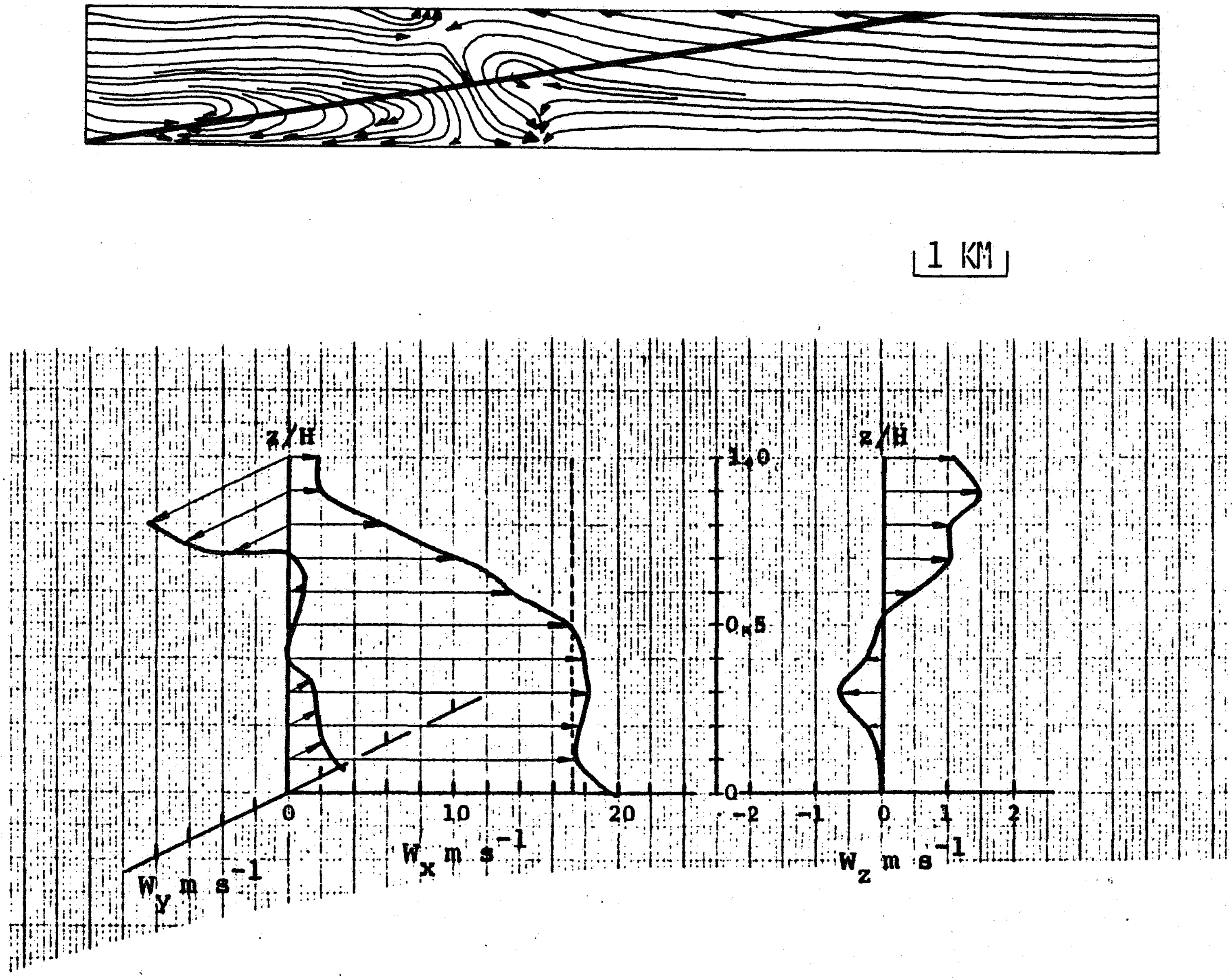

Figure 2B-17 Typical Wind Profiles along a 3° Glide Slope: Case 17(Q) Series No. 1837, 23 May 74, $\overline{W}_x$ = 17.5 m s^{-1}, H = 11428 tan 3° (m)

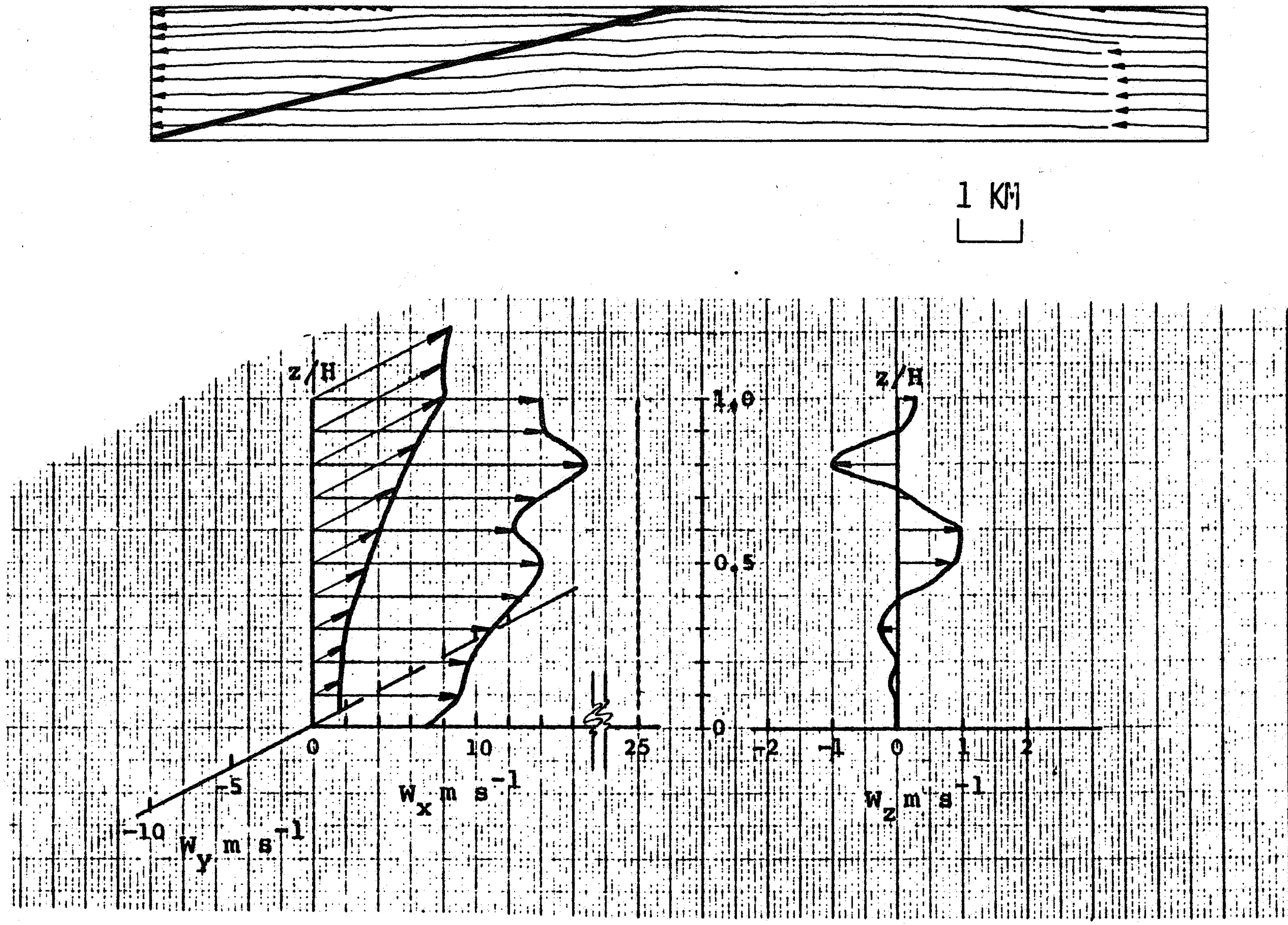

Figure 2B-18 Typical Wind Profiles along a 3° Glide Slope: Case 18(R) Series No. 1651, 19 Apr 72, $\overline{W}_x$ = 25.0 m s^{-1}, H = 16000 tan 3° (m)

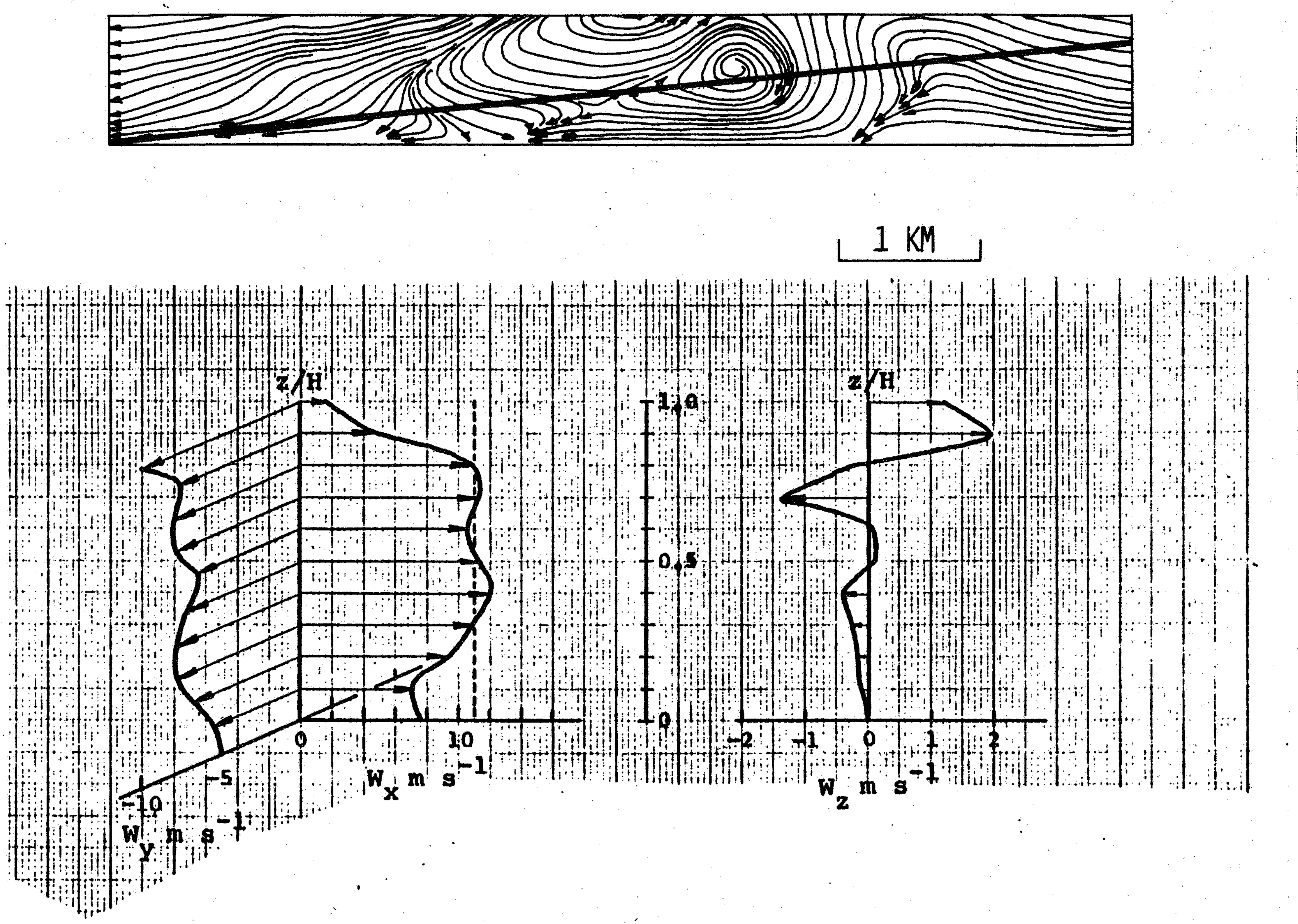

Figure 2B-19 Typical Wind Profiles along a 3° Glide Slope: Case 19(S) Series No. 1904, 26 May 71, $\overline{W}_x = 11.0$ m s^{-1}, H = 7143 tan 3° (m)

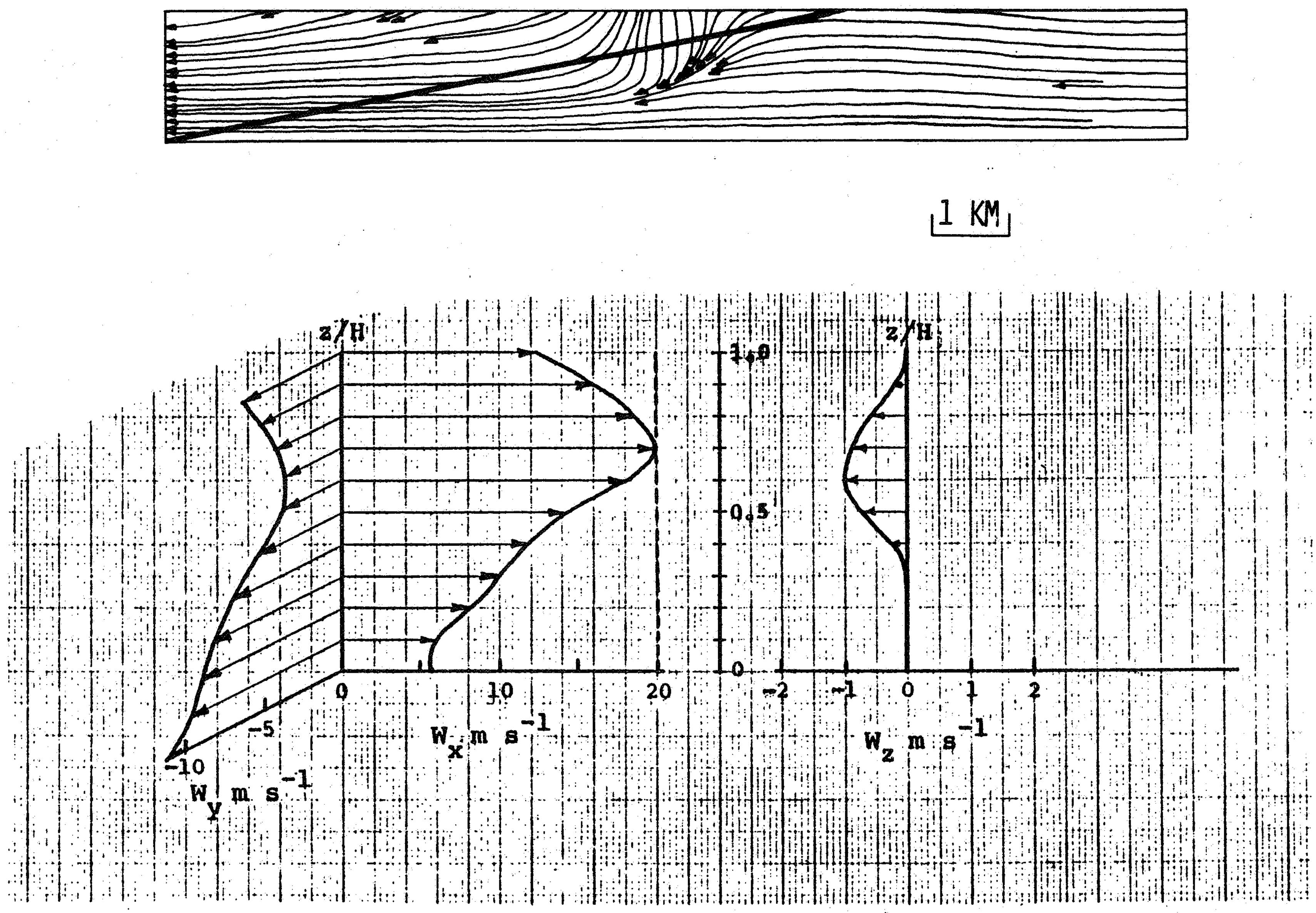

Figure 2B-20 Typical Wind Profiles along a 3° Glide Slope: Case 20(T) Series No. 0029, 21 Apr 72, $\overline{W}_x = 19.9$ m s^{-1}, H = 13333 tan 3° (m)

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APPENDIX 2C

COMPUTER PROGRAM FOR CALCULATION OF TURBULENT THUNDERSTORM WIND FIELDS

This appendix describes a computer program used to obtain the longitudinal, lateral, and vertical wind speeds at a given point (x,z) and all six velocity gradients at that point. The computer program has the option of superimposing a non-Gaussian turbulent field on the thunderstorm wind speeds. When the turbulence option is utilized, an input for time is required. The specified time designates to the program the period over which the turbulent fluctuations are computed.

The subroutine VELO calls seven additional subroutines as schematically illustrated in Figure 2C-1. These seven subroutines are entitled TURB, ROMDON, FILTER, GAUSS, FFT, WIND, and BUILD.

Program Description

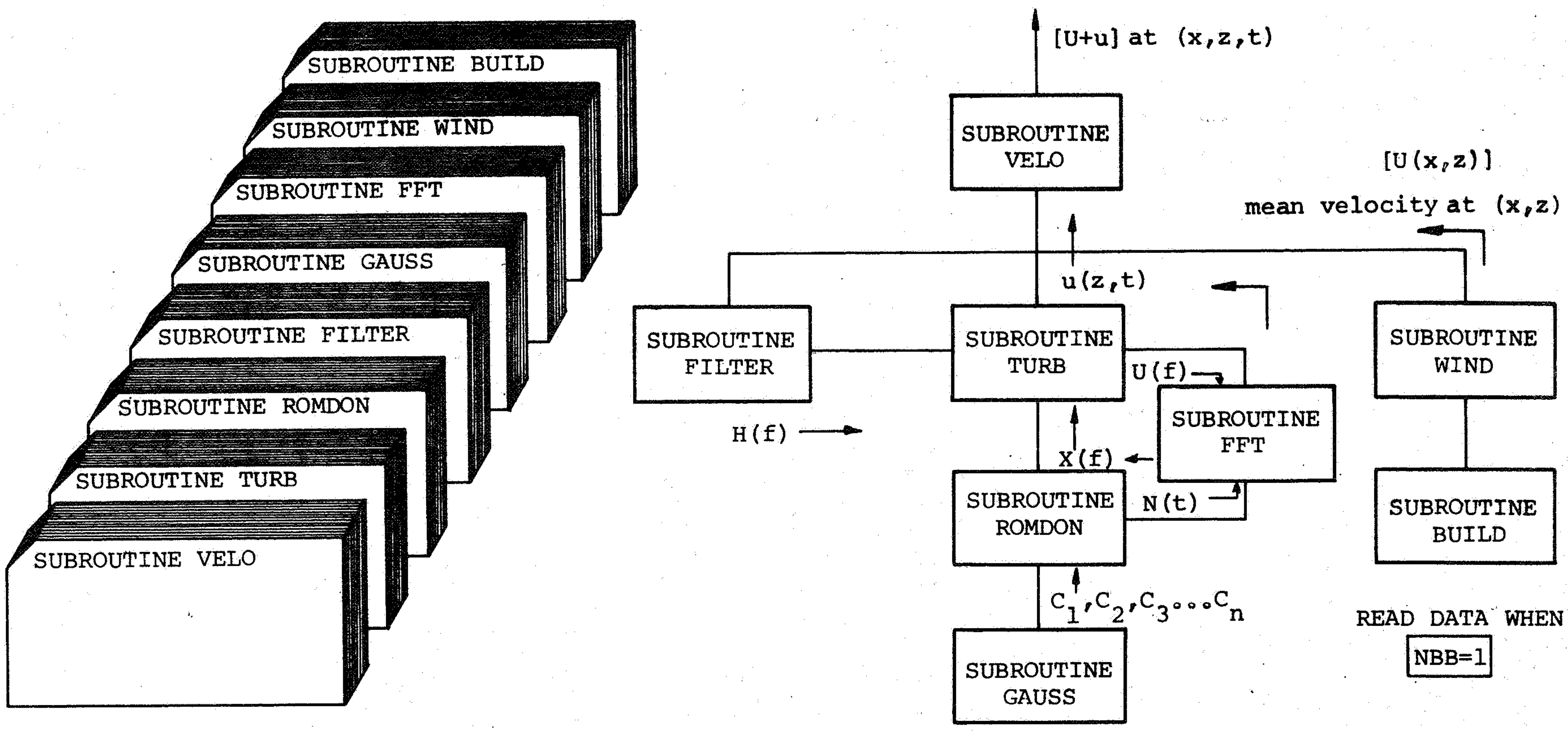
The program is written in FORTRAN IV and generates the wind field with turbulence superimposed for (x,z,T) inputs from the calling flight simulator program.

Subroutine VELO

For the given position and time the VELO subroutine furnish the wind velocity [U,V,W output] and velocity gradient [UDX,UDZ,VDX,VDZ,WDX,WDZ, output] in a flow field which is one of 20 cases of cold air outflow from thunderstorms detected by National Severe Storms Laboratory during 1971 through 1974 [2-1].

Also, a non-Gaussian Dryden spectrum turbulence fluctuation is added to the wind velocity.

VELO first calls the subroutine FILTER which sets up the transfer function for tailoring the random signal. It then calls subroutine TURB. The subroutine TURB processes the random signal generated in subroutine ROMDON through the prescribed filter system and outputs fluctuations w_x, w_y and w_z



$C_1 \circ\circ\circ C_n$ = Random Signal (Gaussian distrb.)

$X(t)$ = Random Function base on $C_1 \cdots C_n$

$X(f)$ = Fourier Transform of $X(t)$

$H(f)$ = Filter Function for Dryden Spectrum

$U(f)$ = $H(f) \circ X(f)$

$U(t)$ = Wind Fluctuation with Dryden Spectrum where

$u(t) = F^{-1}\ [U(f)]$ (inverse Fourier Transform)

Figure 2C-1 Schematic of VELO Subroutine

C-3

having a non-Gaussian distribution with a Dryden spectrum form (Equation 2-4). The transfer to VELO is achieved with a common statement. VELO then calls subroutine WIND to obtain the mean wind velocities at (x,z) to which the corresponding fluctuations are added. The wind speed and wind speed gradients are then computed and the data is output in units of m s^{-1} and s^{-1}, respectively.

Nomenclature

Subroutine VELO(X,Z,T,HAM,NBB,U,V,W,UDX,UDZ,VDX,VDZ,WDX,WDZ)

X	Position vector in longitudinal direction (user's units)	[INPUT]
Z	Position vector in vertical direction (user's units)	[INPUT]
T	Controls time period of turbulent signal (sec)	[INPUT]
HAM	Ratio of unit (meter/user's units)	[INPUT]
NBB	Integer number for calling a new thunderstorm case. NBB=1 calls a new thunderstorm data set into storage	[INPUT] [OUTPUT]
U	Velocity in longitudinal direction (m s^{-1})	[OUTPUT]
V	Velocity in vertical direction (m s^{-1})	[OUTPUT]
W	Velocity in lateral direction (m s^{-1})	[OUTPUT]
UDX	Longitudinal velocity gradient in x direction (s^{-1})	[OUTPUT]
UDZ	Longitudinal velocity gradient in z direction (s^{-1})	[OUTPUT]
VDX	Vertical velocity gradient in x direction (s^{-1})	[OUTPUT]
VDZ	Vertical velocity gradient in z direction (s^{-1})	[OUTPUT]
WDX	Lateral velocity gradient in x direction (s^{-1})	[OUTPUT]
WDZ	Lateral velocity gradient in z direction (s^{-1})	[OUTPUT]

T is incremented with each integration time step of the calling program and is a control variable for the length of the random, turbulent signal generated. When VELO is first called in it generates a turbulent signal at height z for a specified time period TEND. Each time VELO is called following the initial case, i.e., NBB = 1, T is compared with TEND, when T ≥ TEND a new turbulent signal at the current height z of time period TEND is generated. Thus a quasi-turbulence variation with height is achieved.

NBB is set equal to unity for the first time VELO is called. It automatically changes NBB = 2 until another thunderstorm is desired at which time the calling program must reset NBB = 1.

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Listing of Subroutine VELO

```
      SUBROUTINE VELO(X,Z,T,HAM,NBB,U,V,W,UDX,UDZ,VDX,VDZ,WDX,WDZ)
      COMMON/ST2/IX
      COMMON/ST4/H(3,3,128)
      COMMON/ST7/DX
      COMMON/ST12/DT,NNN
      COMMON/ST13/GG(3,128)
      IF(NBB-1) 101,101,105
101   IX=65549
      CALL FILTER(Z)
      CALL TURB(Z)
      TEND=0.
      NCC=0
103   TEND=TEND+DT*NNN
105   IF(T-TEND) 109,108,108
108   CALL TURB(Z)
      NCC=NCC+1
      GO TO 103
109   ER=T/DT
      NT=ER+1-NNN*NCC
      UP=GG(1,NT)
      VP=GG(2,NT)
      WP=GG(3,NT)
      CALL WIND(X,Z,HAM,NBB,WX,WZ,WY,WXX,WXZ,WZX,WZZ,WYX,WYZ)
      U=WX+UP
      V=WZ+VP
      W=WY+WP
      NU=NT+1
      UDX=WXX+(GG(1,NU)-UP)/DX
      VDX=WZX+(GG(2,NU)-VP)/DX
      WDX=WYX+(GG(2,NU)-WP)/DX
      UDZ=WXZ
      VDZ=WZZ
      WDZ=WYZ
      RETURN
      END
```

Subroutine TURB

The subroutine TURB is called by the subroutine VELO. This subroutine carries out the calculation for the turbulent fluctuations based on non-Gaussian turbulence model of Reeves, et al. [2-3]. A Dryden spectrum is used. A schematic of the non-Gaussian turbulence simulation model is given in Figure 2C-2.

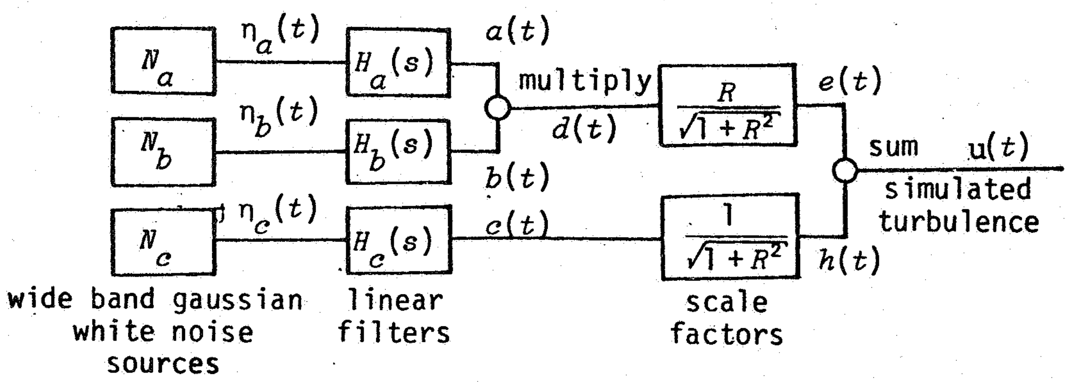

Figure 2C-2 Physical Interpretation of a Single Component of the Non-Gaussian Turbulence Model

TURB first calls the subroutine ROMDON to obtain three independent discrete Gaussian white noise random functions N_a, N_b, N_c. These signals are processed through a common statement by the subroutine FILTER having the filter function H_a, H_b, H_c.

After mathematical analysis the simulated turbulent fluctuation $w_x(t)$, $w_y(t)$ and $w_z(t)$ are determined and with a common statement returned to VELO.

<u>Listing of Subroutine TURB</u>

```
      SUBROUTINE TURB(Z)
      DIMENSION RR(3,128),RI(3,128),XR(128),XI(128) ,GH(3,3,128)
      COMMON/ST2/IX
      COMMON/ST4/H(3,3,128)
      COMMON/ST8/NT2
      COMMON/ST12/DT,NNN
      COMMON/ST13/GG(3,128)
      NT=NNN
      R=1.
      IT=1
 99   J=1
      CALL ROMDON(RR,RI,NT,NT2)
100   DO 110 K=1,NT
      XR(K)=H(IT,J,K)*RR(J,K)
      XI(K)=0.
110   CONTINUE
      CALL FFT(XR,XI,NT,NT2,2)
      DO 111 K=1,NT
      GH(IT,J,K)=XR(K)
111   CONTINUE
      J=J+1
      IF(J-3) 100,100,130
```

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```
130 DO 140 K=1,NT
    XR(K)=GH(IT,1,K)*GH(IT,2,K)
    GG(IT,K)=R/(1.+R*R)**0.5*XR(K)+1./(1.+R*R)**0.5*GH(IT,3,K)
140 CONTINUE
    IT=IT+1
    IF(IT-3) 99,99,150
150 CONTINUE
    WRITE(6,2)
    DO 160 I=1,3
    WRITE(6,1) (GG(I,K),K=1,NT)
    IF(I-2)154,155,160
154 WRITE(6,3)
    GO TO 160
155 WRITE(6,4)
160 CONTINUE
  1 FORMAT(10(1X,E11.4))
  2 FORMAT(15X,'LONGITUINAL')
  3 FORMAT(15X,'VERTICAL')
  4 FORMAT(15X,'LATERAL')
    RETURN
    END
```

Subroutine ROMDON

The subroutine ROMDON is called by the subroutine TURB. This subroutine calls the subroutine GAUSS which generates a random Gaussian white noise signal. Three series of normalized zero mean random function $N_a(t)$, $N_b(t)$ and $N_c(t)$ are transferred to the subroutine FFT which fast Fourier transforms $N_a(t)$, $N_b(t)$ and $N_c(t)$ and returns the transformed signal to TURB.

Nomenclature

Subroutine ROMDON (RR,RI,NT,NT2)

RR(1,J)	Real part of Fourier transform of $N_a(t)$	[OUTPUT]
RR(2,J)	Real part of Fourier transform of $N_b(t)$	[OUTPUT]
RR(3,J)	Real part of Fourier transform of $N_c(t)$	[OUTPUT]
RI(1,J)	Imaginary part of Fourier transform of $N_a(t)$	[OUTPUT]
RI(2,J)	Imaginary part of Fourier transform of $N_b(t)$	[OUTPUT]
RI(3,J)	Imaginary part of Fourier transform of $N_c(t)$	[OUTPUT]
NT	Integer number of discrete noise signal, usually NT = 128	[INPUT]
NT2	$(2)^{NT2}$ = NT (for example, if NT = 128, NT2 = 7)	

Listing of Subroutine ROMDON

```
      SUBROUTINE ROMDON(RR,RI,NT,NT2)
      COMMON/ST2/IX
      DIMENSION RR(3,128),RI(3,128),XR(128),XI(128)
      DO 110 I=1,3
      SUM=0.
      DO 105 J=1,NT
      CALL GAUSS(IX,1.,0.,R)
      RR(I,J)=R
      SUM=SUM+RR(I,J)
105   CONTINUE
      AVE=SUM/NT
      SIG=0.
      DO 106 J=1,NT
      RR(I,J)=RR(I,J)-AVE
      SIG=SIG+RR(I,J)**2
106   CONTINUE
      SIG=(SIG/NT)**0.5
      DO 107 J=1,NT
      RR(I,J)=RR(I,J)/SIG
107   CONTINUE
      DO 108 J=1,NT
      XR(J)=RR(I,J)
      XI(J)=0.
108   CONTINUE
      CALL FFT(XR,XI,NT,NT2,1)
      DO 109 J=1,NT
      RR(I,J)=XR(J)
      RI(I,J)=XI(J)
109   CONTINUE
110   CONTINUE
      RETURN
      END
```

Subroutine GAUSS

The subroutine GAUSS is called by the subroutine ROMDON. Each time GAUSS is called it generates a new random number. Random numbers generated by GAUSS are white noise having a Gaussian distribution.

Nomenclature

Subroutine GAUSS(IX,S,AM,V)

IX	Arbitrary starting number, IX = 65549	[INPUT] [OUTPUT]
S	Adjusting number, setting S = 1.0 gives standard deviation of unity	[INPUT]

AM Adjusting number, setting AM = 0.0 gives zero mean [INPUT]

V Random number output [OUTPUT]

Listing of Subroutine GAUSS

```
      SUBROUTINE GAUSS(IX,S,AM,V)
      REAL*8 Y
      A=0.0
      DO 50 I=1,12
      IY=IX*65539
      IF(IY) 5,6,6
    5 IY=IY+2147483647+1
    6 Y=IY
      Y=Y*0.4656613D-9
      IX=IY
   50 A=A+Y
      V=(A-6.0)*S+AM
      RETURN
      END
```

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Subroutine Filter

The subroutine FILTER is called by the subroutine VELO. The input list contains the height z. This subroutine sets up nine filter functions shown in Table 2C-1, for generating the three direction fluctuating signal, w_x, w_y and w_z.

These are returned to TURB through a common statement where H(IT,J,K) equals $H_a(K)$ if J = 1, $H_b(K)$ if J = 2 and $H_c(K)$ if J = 3. The value of IT = 1 specifies longitudinal fluctuations; IT = 2 vertical and IT = 3 lateral.

Listing of Subroutine FILTER

```
      SUBROUTINE FILTER(Z)
      COMMON/ST4/H(3,3,128)
      COMMON/ST12/DT,NNN
      NT=NNN
      Z1=Z*3.281
      UMEAN=8.
      ALU=(Z1/(0.177+0.832*0.001*Z1)**1.2)/3.281
      ALV=ALU
```

TABLE 2C-1

TRANSFER FUNCTIONS OF THE NON-GAUSSIAN MODEL

Longitudinal Component		
$H_a(s)$	$H_b(s)$	$H_c(s)$
$\dfrac{4\sigma_{w_x}\dfrac{L_{w_x}}{W_x}}{1+\dfrac{2L_{w_x}}{W_x}s}$	$\dfrac{1}{1+\dfrac{2L_{w_x}}{W_x}s}$	$\dfrac{\sigma_{w_x}\left(\dfrac{2L_{w_x}}{W_x}\right)^{1/2}}{1+\dfrac{L_{w_x}}{W_x}s}$
Lateral Component		
$H_a(s)$	$H_b(s)$	$H_c(s)$
$\dfrac{\sigma_{w_y}(128)^{1/2}\left(\dfrac{L_{w_y}}{W_x}\right)^{2}}{1+\dfrac{2L_{w_y}}{W_x}s}$	$\dfrac{s}{\left(1+\dfrac{2L_{w_y}}{W_x}s\right)^{2}}$	$\dfrac{\sigma_{w_y}\left(\dfrac{L_{w_y}}{W_x}\right)^{1/2}\left(1+\sqrt{3}\,\dfrac{L_{w_y}}{W_x}s\right)}{\left(1+\dfrac{L_{w_y}}{W_x}s\right)^{2}}$
Vertical Component		
$H_a(s)$	$H_b(s)$	$H_c(s)$
$\dfrac{\sigma_{w_z}(128)^{1/2}\dfrac{L_{w_z}}{W_x}^{2}}{1+\dfrac{2L_{w_z}}{W_x}s}$	$\dfrac{s}{\left(1+\dfrac{2L_{w_z}}{W_x}s\right)^{2}}$	$\dfrac{\sigma_{w_z}\left(\dfrac{L_{w_z}}{W_x}\right)^{1/2}\left(1+\sqrt{3}\,\dfrac{L_{w_z}}{W_x}s\right)}{\left(1+\dfrac{L_{w_z}}{W_x}s\right)^{2}}$

```
      ALW=ALU
      AMU=0.106*8./(0.177+0.832*0.001*Z1)**0.4
      AMV=AMU
      AMW=AMU
      UOU=ALU/UMEAN
      VOU=ALV/UMEAN
      WOU=ALW/UMEAN
      DD=128**0.5
      DE=3.**0.5
      FC=1./(2.*DT)
      DO 110 K=1,NT
      S=FC*(K-1)/NT
      H(1,1,K)=4.*AMU*UOU/(1.+2.*UOU*S)
      H(1,2,K)=1./(1.+2.*UOU*S)
      H(1,3,K)=AMU*(2.*UOU)**0.5/(1.+UOU*S)
      H(2,1,K)=AMU*DD*VOU**2/(1.+2.*VOU*S)
      H(2,2,K)=S/(1.+2.*VOU*S)**2
      H(2,3,K)=AMV*VOU**0.5*(1.+DE*VOU*S)/(1.+VOU*S)**2
      H(3,1,K)=AMW*DD*WOU**2/(1.+2.*WOU*S)
      H(3,2,K)=S/(1.+2.*WOU*S)**2
      H(3,3,K)=AMW*WOU**0.5*(1.+DE*WOU*S)/(1.+WOU*S)**2
  110 CONTINUE
      RETURN
      END
```


Subroutine FFT

The subroutine FFT provides a discrete fast Fourier or inverse Fourier transformation and it is called by the subroutine ROMDON and the subroutine TURB.

In the subroutine ROMDON, FFT is utilized to transform N_a, N_b and N_c from the time domain to the frequency domain.

In subroutine TURB, after the frequency function has passed through the filter function, FFT is used to transform the frequency function back to the time functions a(t), b(t) and c(t).

Nomenclature

Subroutine FFT(XR,XI,N,NU,NGG)

XR	Array of the real part of the function to be transformed	[INPUT] [OUTPUT]
XI	Array of the imaginary part of the function to be transformed	[INPUT] [OUTPUT]
N	Total number of the Array (N); usually N=128	[INPUT]

NU	(2)NU=N; usually NU=7 which gives N=128	[INPUT]
NGG	If NGG=1, the subroutine performs the Fourier Transform If NGG=2, the subroutine performs the Inverse Fourier Transform	[INPUT]

Listing of Subroutine FFT

```
      SUBROUTINE FFT(XR,XI,N,NU,NGG)
      DIMENSION XR(N),XI(N)
      IF(NGG.EQ.1) GO TO 321
      DO 320 I=1,N
320   XI(I)=-XI(I)
321   N2=N/2
      NU1=NU-1
      K=0
      DO 100 L=1,NU
102   DO 101 I=1,N2
      P=IBITR(K/2**NU1,NU)
      ARG=6.283185*P/FLOAT(N)
      C=COS(ARG)
      S=SIN(ARG)
      K1=K+1
      K1N2=K1+N2
      TR=XR(K1N2)*C+XI(K1N2)*S
      TI=XI(K1N2)*C-XR(K1N2)*S
      XR(K1N2)=XR(K1)-TR
      XI(K1N2)=XI(K1)-TI
      XR(K1)=XR(K1)+TR
      XI(K1)=XI(K1)+TI
101   K=K+1
      K=K+N2
      IF(K.LT.N) GO TO 102
      K=0
      NU1=NU1-1
100   N2=N2/2
      DO 103 K=1,N
      I=IBITR(K-1,NU)+1
      IF(I.LE.K) GO TO 103
      TR=XR(K)
      TI=XI(K)
      XR(K)=XR(I)
      XI(K)=XI(I)
      XR(I)=TR
      XI(I)=TI
103   CONTINUE
      IF(NGG.EQ.1) GO TO 121
      DO 124 I=1,N
      XR(I)=XR(I)/N
      XI(I)=XI(I)/N
```

```
124 CONTINUE
121 RETURN
    END
    FUNCTION IBITR(J,NU)
    J1=J
    IBITR=0
    DO 200 I=1,NU
    J2=J1/2
    IBITR=IBITR*2+(J1-2*J2)
200 J1=J2
    RETURN
    END
```


Subroutine WIND

The WIND subroutine is called by the subroutine VELO for the given position (x,z) from VELO. Interpolation by an area-weighting method for the velocity at the point x,z in the flow field based on the tabulated data for the given thunderstorm data set placed in storage by subroutine BUILD. The area-weighting interpolation method is illustrated in Figure 2C-3.

The area-weighting scheme calculates the velocity and velocity gradient of each point by using the four nearest neighboring grid point velocities.

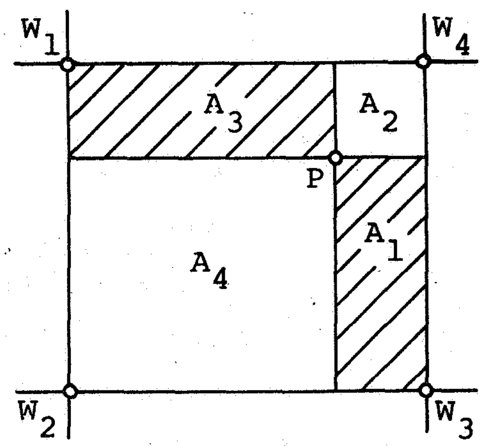

Figure 2C-3 Area-Weighting Technique

The velocity at point P is given by:

$$W_p = \frac{1}{A}[A_1W_1 + A_2W_2 + A_3W_3 + A_4W_4]$$

where

$$A = A_1 + A_2 + A_3 + A_4$$

The same interpolation method is used for the velocity gradients.

Nomenclature

Subroutine WIND (X,Z,HAM,KCK,WX,WZ,WY,WXX,WXZ,WZX,WZZ,WYX,WYZ)

(X,Z)	Position vector (users units)	[INPUT]
HAM	Ratio of units (users units)	[INPUT]
KCK	Integer number for storing a new thunderstorm case. If KCK=1, the subroutine BUILD is called and a new thunderstorm data set is read in; otherwise KCK=2.	[INPUT]
WX	Velocity in longitudinal direction	
WZ	Velocity in vertical direction	[OUTPUT]
WY	Velocity in lateral direction	
WXX,WXZ	Velocity gradient	
WZX,WZZ	Velocity gradient	[OUTPUT]
WYX,WYZ	Velocity gradient	

Listing of Subroutine WIND

```
      SUBROUTINE WIND(X,Z,HAM,KCK,WX,WZ,WY,WXX,WXZ,WZX,WZZ,WYX,WYZ)
      DIMENSION DXX(2,2),DXZ(2,2),DZX(2,2),DZZ(2,2),DYX(2,2),
     &DYZ(2,2)
      COMMON/TT/A(41,11,3),DX,DZ
 11   FORMAT(//,'*** X-VALUE IN SUBROUTINE INTER IS OUTSIDE FLOW ',
     $'REGION   X = ',E13.6,//)
 21   FORMAT(//,'*** Y-VALUE IN SUBROUTINE INTER IS OUTSIDE FLOW ',
     $'REGION   Y = ',E13.6,//)
 31   FORMAT(2X,'***POINT X = ',E13.6,' Z = ',E13.6,' IS OUTSIDE')
      IF(KCK.NE.1) GO TO 100
      CALL BUILD
      KCK=2
```

```
100 XP=X*HAM
    ZP=Z*HAM
    IF(XP.LT.0..OR.ZP.LT.0.) GO TO  210
    DO 101 I=2,41
    X1=(I-1)*DX
    IF(XP.LE.X1) GO TO 102
101 CONTINUE
    WRITE(6,11) XP
102 IP=I-1
    DO 103 J=2,11
    Z1=(J-1)*DZ
    IF(ZP.LE.Z1) GO TO 104
103 CONTINUE
    WRITE(6,21) ZP
104 JP=J-1
    ALFA=(XP-(IP-1)*DX)/DX
    BETA=(ZP-(JP-1)*DZ)/DZ
    K=1
105 VAL=(1.0-ALFA)*(1.0-BETA)*A(IP,JP,K)+BETA*(1.0-ALFA)*A(IP,JP
   $+1,K)+ALFA*(1.0-BETA)*A(IP+1,JP,K)+ALFA*BETA*A(IP+1,JP+1,K)
    IF(K-2) 106,107,108
106 WX=VAL
107 WZ= VAL
    K=K+1
    GO TO 105
108 WY=VAL
    DO 208 I=1,2
    DO 208 J=1,2
    IF(IP.EQ.1.AND.I.EQ.1) GO TO 201
    IF(IP.EQ.40.AND.I.EQ.2)  GO TO 202
    DXX(I,J)=0.5/DX*(A(IP+I,JP+J-1,1)-A(IP+I-2,JP+J-1,1))
    DZX(I,J)=0.5/DX*(A(IP+I,JP+J-1,2)-A(IP+I-2,JP+J-1,2))
    DYX(I,J)=0.5/DX*(A(IP+I,JP+J-1,3)-A(IP+I-2,JP+J-1,3))
    GO TO 203
201 DXX(1,J)=(A(2,JP+J-1,1)-A(1,JP+J-1,1))/DX
    DZX(1,J)=(A(2,JP+J-1,2)-A(1,JP+J-1,2))/DX
    DYX(1,J)=(A(2,JP+J-1,3)-A(1,JP+J-1,3))/DX
    GO TO 203
202 DXX(2,J)=(A(41,JP+J-1,1)-A(40,JP+J-1,1))/DX
    DZX(2,J)=(A(41,JP+J-1,2)-A(40,JP+J-1,2))/DX
    DYX(2,J)=(A(41,JP+J-1,3)-A(40,JP+J-1,3))/DX
203 IF(JP.EQ.1.AND.J.EQ.1) GO TO 204
    IF(JP.EQ.10.AND.J.EQ.2) GO TO 205
    DXZ(I,J)=0.5/DZ*(A(IP+I-1,JP+J,1)-A(IP+I-1,JP+J-2,1))
    DZZ(I,J)=0.5/DZ*(A(IP+I-1,JP+J,2)-A(IP+I-1,JP+J-2,2))
    DYZ(I,J)=0.5/DZ*(A(IP+I-1,JP+J,3)-A(IP+I-1,JP+J-2,3))
    GO TO 208
204 DXZ(I,1)=(A(IP+I-1,2,1)-A(IP+I-1,1,1))/DZ
    DZZ(I,1)=(A(IP+I-1,2,2)-A(IP+I-1,1,2))/DZ
    DYZ(I,1)=(A(IP+I-1,2,3)-A(IP+I-1,1,3))/DZ
    GO TO 208
```

```
205 DXZ(I,2)=(A(IP+I-1,11,1)-A(IP+I-1,10,1))/DZ
    DZZ(I,2)=(A(IP+I-1,11,2)-A(IP+I-1,10,2))/DZ
    DYZ(I,2)=(A(IP+I-1,11,3)-A(IP+I-1,10,3))/DZ
208 CONTINUE
    WXX=(1.0-ALFA)*(1.0-BETA)*DXX(1,1)+BETA*(1.0-ALFA)*DXX(1
   *,2)+ALFA*(1.0-BETA)*DXX(2,1)+ALFA*BETA*DXX(2,2)
    WXZ=(1.0-ALFA)*(1.0-BETA)*DXZ(1,1)+BETA*(1.0-ALFA)*DXZ(1
   *,2)+ALFA*(1.0-BETA)*DXZ(2,1)+ALFA*BETA*DXZ(2,2)
    WZX=(1.0-ALFA)*(1.0-BETA)*DZX(1,1)+BETA*(1.0-ALFA)*DZX(1
   *,2)+ALFA*(1.0-BETA)*DZX(2,1)+ALFA*BETA*DZX(2,2)
    WZZ=(1.0-ALFA)*(1.0-BETA)*DZZ(1,1)+BETA*(1.0-ALFA)*DZZ(1
   *,2)+ALFA*(1.0-BETA)*DZZ(2,1)+ALFA*BETA*DZZ(2,2)
    WYX=(1.0-ALFA)*(1.0-BETA)*DYX(1,1)+BETA*(1.0-ALFA)*DYX(1
   *,2)+ALFA*(1.0-BETA)*DYX(2,1)+ALFA*BETA*DYX(2,2)
    WYZ=(1.0-ALFA)*(1.0-BETA)*DYZ(1,1)+BETA*(1.0-ALFA)*DYZ(1
   *,2)+ALFA*(1.0-BETA)*DYZ(2,1)+ALFA*BETA*DYZ(2,2)
    GO TO 215
210 WRITE(6,31) XP,ZP
215 RETURN
    END
```

Subroutine BUILD

The subroutine WIND is called by the subroutine BUILD which reads individual sets of wind speed data into storage. The thunderstorm cases are read in sequential order based on the numbering system utilized in this report; that is, Case 1 corresponding to Case A, Serial No. 0446 of Reference [2-1] is read in first and remains in storage until KCK in list statement of subroutine WIND is assigned the value 1. The subroutine WIND then calls the next thunderstorm case in numerical order.

In subroutine BUILD, the grid system for the wind field is shown in Figure 2C-4 where IT=41 and JT=11.

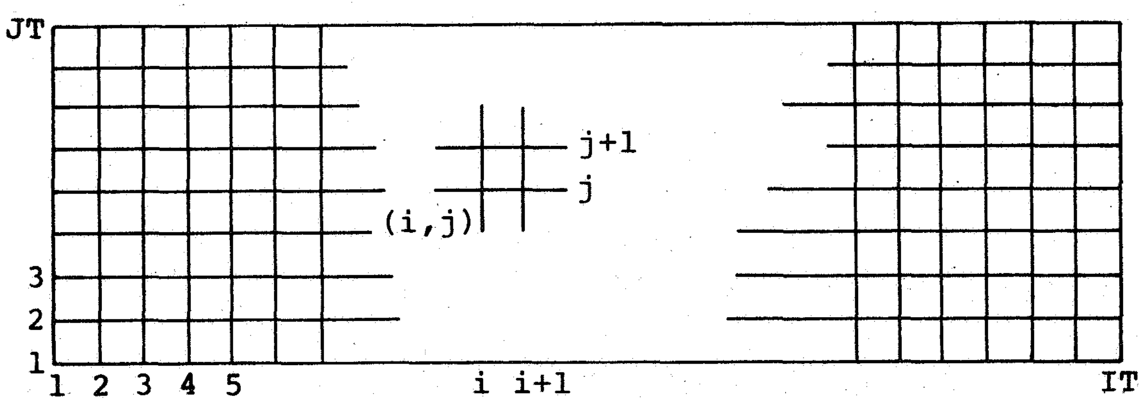

Figure 2C-4 Grid System of Wind Field

At point (I,J) the normal velocity $W_x(I,J)$ and vertical velocity $W_z(I,J)$ are stored as

$$A(I,J,1) = W_x(I,J); \quad A(I,J,2) = W_z(I,J)$$

A common statement is used to transfer the data A(I,J,K) to the subroutine WIND.

<u>Listing of Subroutine BUILD</u>


```
      SUBROUTINE BUILD
      DIMENSION IB(41)
      COMMON/TT/A(41,11,3),DX,DZ
    1 FORMAT(20X,'HORIZONTAL  VELOCITY ' ,/,/)
    2 FORMAT(13F6.2)
    3 FORMAT(4X,I2,2X,21F5.1)
    4 FORMAT(/,/,20X,'VERTICAL     VELOCITY ' ,/,/)
    5 FORMAT(2F10.4,F5.1)
    6 FORMAT(5X,'DX =',F8.2,3X,'DZ =',F8.2,3X,'MEAN VX =',F5.1)
    7 FORMAT(3X,'J/I',2X,21(I3,2X))
    8 FORMAT(/,/,20X,'LATERAL   VELOCITY',/,/)
      READ(5,5) DX,DZ,UMEAN
      WRITE(6,6) DX,DZ,UMEAN
      DO 90 I=1,41
   90 IB(I)=I
      K=1
      WRITE(6,1)
  100 WRITE(6,7) (IB(I),I=1,41,2)
      DO 105 J=1,11
      READ(5,2) (A(I,J,K),I=1,41)
      IF(K.GE.2) GO TO 105
      DO 101 I=1,41
      A(I,J,K)=A(I,J,K)+UMEAN
  101 CONTINUE
  105 CONTINUE
      DO 102 J=1,11
      JKJ=12-J
  102 WRITE(6,3) JKJ,(A(I,JKJ,K),I=1,41,2)
      K=K+1
      IF(K-3) 103,104,106
  103 WRITE(6,4)
      GO TO 100
  104 WRITE(6,8)
      GO TO 100
  106 RETURN
      END
```

APPENDIX 3A

TABULATED STABLE AND NEUTRAL BOUNDARY LAYER DATA

This appendix contains the tabulated data interpolated from the extensive measurement of wind speeds under varying conditions of stability reported by Clarke and Hess [3-1].

The tabulated values are the longitudinal and lateral wind speeds $\hat{W}_x(\hat{z}) = \hat{W}_x/u_*$ and $\hat{W}_y(\hat{z}) = W_y/u_*$ for neutral and stable boundary layers for $\mu \geq 0$ where the dimensionless height $\hat{z} = zf/u_*$. The data actually stored on computer cards and used with the computer lookup routine given in Appendix 3C is

$$\Delta\hat{W}_x = \hat{W}_x(\hat{z} = 0.15) - \hat{W}_x(\hat{z})$$

and

$$\Delta\hat{W}_y = \hat{W}_y(\hat{z}) - \hat{W}_y(\hat{z} = 0.15)$$

These data have been converted to $\hat{W}_x$ and $\hat{W}_y$ using the relationships

$$\hat{W}_x(\hat{z}) = \Delta\hat{W}_x(\hat{z} = 0.001) - \Delta\hat{W}_x(\hat{z}) + \hat{W}_x(\hat{z} = 0.001)$$

and

$$\hat{W}_y(\hat{z}) = \Delta\hat{W}_y(\hat{z}) - \Delta\hat{W}_y(\hat{z} = 0.001)$$

where

$$\hat{W}_x(\hat{z} = 0.001) = \kappa^{-1}[\ln(0.001\ Ro\ \ + 1) + 0.01125\ \mu]$$

To extend the tables to values of $\hat{z} < 0.001$, wind speeds can be computed from

$$\hat{W}_x(\hat{z}) = \frac{1}{\kappa}\{\ln(Ro\ \hat{z} + 1) + 4.5\ \hat{z}\mu/\kappa\};\quad \mu \geq 0,\ 0 \leq \hat{z} \leq 0.001$$

and

$\hat{W}_y(\hat{z}) = 0$

The data are presented in a right-hand coordinate system with W_x positive in the direction from left to right and W_y positive into the plane of the paper.

Tabulated results are given for values of μ ranging from 0 to 200 in increments of $\Delta\mu = 10$ listed across the top of the tables and for values of $\hat{z}$ ranging from 0.001 to 0.15 listed in the vertical left-hand column.

From these tables the user can construct wind speed profiles for given values of μ, u_* and f. Note that $\hat{z} = zf/u_*$ and $Ro = u_*/zf$.

Table 3A-1(a) Longitudinal Wind Speed, $\hat{W}_x$, Ro $=10^7$

	0	10	20	30	40	50	60	70	80	90	100
0.150	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.8	75.8
0.140	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.8	75.8
0.130	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.8	75.8
0.120	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.8	75.8
0.110	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.8	75.8
0.100	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.5	73.6	75.5
0.090	42.0	46.5	51.2	56.3	60.1	63.4	66.1	68.8	71.4	73.3	74.9
0.080	42.0	46.5	51.2	56.3	60.1	63.4	65.9	68.2	70.3	72.0	73.5
0.070	42.0	46.5	51.2	56.3	59.9	62.7	65.0	67.1	69.0	70.6	72.1
0.060	41.9	46.4	51.0	56.1	59.2	61.4	63.4	65.5	67.6	69.2	70.7
0.050	39.9	43.9	48.3	53.1	56.6	59.3	61.4	63.5	65.5	67.2	68.7
0.040	37.9	41.8	45.9	50.6	54.0	56.9	59.0	60.9	62.7	64.0	65.2
0.030	35.9	39.7	43.6	48.2	51.3	53.8	55.8	57.5	58.6	59.4	60.0
0.020	33.9	37.7	41.5	45.0	46.3	46.5	46.6	47.1	47.2	48.3	50.0
0.010	29.1	31.5	33.8	35.8	36.2	35.9	35.8	35.7	35.7	36.5	37.9
0.005	25.7	27.0	28.1	29.2	29.5	29.5	29.7	29.8	29.9	30.4	31.2
0.001	23.0	23.3	23.6	23.9	24.1	24.4	24.7	25.0	25.3	25.6	25.8

	100	110	120	130	140	150	160	170	180	190	200
0.150	75.8	77.3	78.6	79.5	80.4	81.2	81.5	81.8	82.1	82.4	82.7
0.140	75.8	77.3	78.6	79.4	80.2	81.0	81.1	81.3	81.6	81.8	82.1
0.130	75.8	77.3	78.4	79.1	79.8	80.5	80.6	80.7	81.0	81.3	81.5
0.120	75.8	77.1	78.2	78.6	79.2	79.7	79.9	80.1	80.4	80.7	80.9
0.110	75.8	76.9	77.7	78.0	78.6	79.3	79.4	79.5	79.7	79.9	80.2
0.100	75.5	76.4	77.1	77.4	78.0	78.8	78.8	78.9	78.9	79.1	79.4
0.090	74.9	75.8	76.5	76.8	77.4	78.2	78.2	78.2	78.1	78.3	78.6
0.080	73.5	74.6	75.4	75.9	76.4	77.1	77.1	77.2	77.1	77.2	77.3
0.070	72.1	73.2	74.1	74.4	75.0	75.7	75.7	75.7	75.7	75.8	75.8
0.060	70.7	71.8	72.5	72.6	73.2	74.1	73.9	73.8	73.9	74.0	74.2
0.050	68.7	69.8	70.6	70.7	71.3	72.1	71.9	71.6	71.4	71.2	71.1
0.040	65.2	66.2	66.9	66.9	67.3	68.1	68.0	67.9	67.8	67.7	67.7
0.030	60.0	60.9	61.5	61.2	61.6	62.4	62.6	62.9	63.1	63.3	63.5
0.020	50.0	51.3	52.3	52.9	53.6	54.5	54.8	55.0	55.3	55.6	55.8
0.010	37.9	38.9	39.8	40.5	41.1	41.7	42.0	42.3	42.6	42.9	43.1
0.005	31.2	31.8	32.4	32.8	33.2	33.7	34.0	34.3	34.5	34.8	35.1
0.001	25.8	26.1	26.4	26.7	27.0	27.2	27.5	27.8	28.1	28.4	28.7

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Table 3A-1(b) Lateral Wind Speed, $\hat{W}_y$, Ro $=10^7$

	0	10	20	30	40	50	60	70	80	90	100
0.150	-18.0	-20.4	-22.9	-25.6	-28.7	-32.0	-31.4	-30.7	-29.8	-28.9	-28.0
0.140	-17.4	-19.6	-22.3	-24.9	-28.0	-31.2	-30.6	-29.8	-28.9	-27.9	-27.0
0.130	-17.1	-19.4	-21.7	-24.2	-27.2	-30.4	-29.7	-28.9	-28.0	-27.0	-26.1
0.120	-17.0	-19.1	-21.2	-23.4	-26.3	-29.5	-28.8	-28.1	-27.1	-26.1	-25.2
0.110	-16.3	-18.4	-20.5	-22.6	-25.3	-28.3	-27.6	-26.7	-25.6	-24.6	-23.7
0.100	-15.5	-17.8	-19.9	-21.8	-24.3	-27.2	-26.2	-25.2	-24.0	-23.0	-22.1
0.090	-14.5	-17.1	-19.4	-20.9	-23.2	-25.9	-24.7	-23.5	-22.3	-21.3	-20.4
0.080	-13.5	-15.5	-17.4	-18.9	-20.9	-23.2	-22.3	-21.4	-20.4	-19.6	-18.8
0.070	-12.1	-13.5	-15.0	-16.5	-18.6	-21.1	-20.3	-19.3	-18.0	-17.2	-16.5
0.060	-10.4	-11.3	-12.4	-13.9	-16.4	-19.4	-18.4	-17.2	-15.2	-14.3	-13.9
0.050	-8.7	-9.8	-10.9	-12.0	-14.2	-17.0	-15.9	-14.7	-13.3	-12.3	-11.5
0.040	-7.0	-8.1	-9.2	-10.2	-12.1	-14.5	-13.3	-12.1	-10.9	-9.9	-9.0
0.030	-5.3	-6.2	-7.2	-8.4	-10.0	-11.8	-10.6	-9.4	-8.2	-7.2	-6.3
0.020	-3.7	-3.9	-4.4	-5.4	-7.1	-9.1	-7.9	-6.8	-5.8	-4.9	-4.0
0.010	-1.8	-1.8	-2.0	-2.5	-3.6	-4.8	-4.1	-3.4	-2.9	-2.4	-1.8
0.005	-0.8	-0.8	-0.9	-1.1	-1.6	-2.1	-1.8	-1.5	-1.3	-1.0	-0.8
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	100	110	120	130	140	150	160	170	180	190	200
0.150	-28.0	-26.8	-25.8	-25.2	-24.2	-23.0	-21.8	-20.5	-19.1	-17.2	-15.0
0.140	-27.0	-25.8	-24.7	-24.2	-23.3	-22.2	-21.1	-19.8	-18.4	-16.5	-14.3
0.130	-26.1	-24.8	-23.8	-23.3	-22.4	-21.4	-20.2	-19.0	-17.6	-15.7	-13.6
0.120	-25.2	-23.9	-22.9	-22.4	-21.6	-20.5	-19.3	-18.0	-16.6	-14.8	-12.8
0.110	-23.7	-22.5	-21.5	-21.0	-20.0	-18.8	-17.9	-16.9	-15.6	-13.8	-11.8
0.100	-22.1	-21.0	-20.0	-19.6	-18.6	-17.3	-16.6	-15.6	-14.6	-13.0	-11.1
0.090	-20.4	-19.4	-18.5	-18.1	-17.1	-15.9	-15.3	-14.7	-13.8	-12.3	-10.5
0.080	-18.8	-17.8	-17.1	-16.7	-15.8	-14.6	-14.0	-13.3	-12.5	-11.2	-9.8
0.070	-16.5	-15.8	-15.3	-15.0	-14.2	-13.3	-12.7	-12.0	-11.3	-10.1	-8.7
0.060	-13.9	-13.5	-13.2	-13.0	-12.5	-11.9	-11.3	-10.7	-10.2	-8.9	-7.2
0.050	-11.5	-11.0	-10.7	-10.6	-10.5	-9.9	-9.7	-9.3	-8.6	-7.3	-5.6
0.040	-9.0	-8.4	-8.0	-8.1	-7.9	-7.7	-7.8	-7.6	-7.0	-5.7	-4.0
0.030	-6.3	-5.7	-5.2	-5.0	-5.0	-5.3	-5.6	-5.8	-5.5	-4.2	-2.4
0.020	-4.0	-3.1	-2.7	-3.1	-3.1	-3.0	-3.5	-3.8	-3.8	-2.8	-1.4
0.010	-1.8	-1.3	-1.0	-1.4	-1.4	-1.2	-1.6	-1.8	-1.9	-1.4	-0.6
0.005	-0.8	-0.6	-0.5	-0.6	-0.6	-0.5	-0.7	-0.8	-0.8	-0.6	-0.3
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3A-2(a) Longitudinal Wind Speed, $\hat{W}_x$, Ro =10^6

	0	10	20	30	40	50	60	70	80	90	100
0.150	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	68.0	70.1
0.140	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	68.0	70.1
0.130	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	68.0	70.1
0.120	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	68.0	70.1
0.110	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	68.0	70.1
0.100	36.3	40.7	45.4	50.5	54.4	57.7	60.4	63.0	65.7	67.9	69.8
0.090	36.3	40.7	45.4	50.5	54.4	57.7	60.3	63.0	65.7	67.6	69.1
0.080	36.3	40.7	45.4	50.5	54.4	57.7	60.1	62.5	64.5	66.2	67.7
0.070	36.3	40.7	45.4	50.5	54.1	57.0	59.2	61.4	63.2	64.9	66.3
0.060	36.1	40.6	45.3	50.3	53.5	55.7	57.7	59.7	61.8	63.5	65.0
0.050	34.1	38.2	42.5	47.4	50.8	53.6	55.6	57.7	59.8	61.5	62.9
0.040	32.1	36.0	40.1	44.8	48.3	51.1	53.2	55.2	56.9	58.3	59.4
0.030	30.1	34.0	38.0	42.5	45.6	48.1	50.0	51.7	52.8	53.6	54.3
0.020	28.1	32.0	35.7	39.2	40.5	40.7	41.0	41.3	41.4	42.5	44.2
0.010	23.3	25.8	28.1	30.0	30.5	30.2	30.1	30.0	29.9	30.8	32.2
0.005	20.0	21.2	22.4	23.4	23.8	23.8	23.9	24.0	24.1	24.7	25.5

	100	110	120	130	140	150	160	170	180	190	200
0.150	70.1	71.6	72.8	73.7	74.6	75.5	75.8	76.1	76.3	76.6	76.9
0.140	70.1	71.6	72.8	73.6	74.4	75.2	75.3	75.5	75.8	76.1	76.4
0.130	70.1	71.5	72.7	73.3	74.0	74.7	74.8	74.9	75.2	75.5	75.8
0.120	70.1	71.4	72.4	72.9	73.4	74.0	74.1	74.3	74.6	74.9	75.2
0.110	70.1	71.1	71.9	72.2	72.8	73.5	73.6	73.8	73.9	74.2	74.4
0.100	69.8	70.7	71.4	71.6	72.2	73.0	73.1	73.1	73.2	73.4	73.7
0.090	69.1	70.0	70.7	71.1	71.7	72.4	72.4	72.4	72.4	72.6	72.8
0.080	67.7	68.8	69.7	70.1	70.7	71.3	71.4	71.4	71.4	71.4	71.5
0.070	66.3	67.5	68.3	68.7	69.2	69.9	69.9	69.9	70.0	70.0	70.0
0.060	65.0	66.0	66.7	66.9	67.5	68.4	68.2	68.1	68.1	68.3	68.4
0.050	62.9	64.1	64.9	65.0	65.6	66.4	66.1	65.9	65.6	65.5	65.4
0.040	59.4	60.5	61.2	61.1	61.6	62.4	62.3	62.2	62.0	62.0	61.9
0.030	54.3	55.2	55.7	55.5	55.9	56.7	56.9	57.1	57.3	57.6	57.8
0.020	44.2	45.5	46.6	47.1	47.9	48.7	49.0	49.3	49.5	49.8	50.1
0.010	32.2	33.2	34.1	34.7	35.3	36.0	36.3	36.5	36.8	37.1	37.4
0.005	25.5	26.1	26.6	27.0	27.5	27.9	28.2	28.5	28.8	29.1	29.3
0.001	20.1	20.4	20.6	20.9	21.2	21.5	21.8	22.1	22.3	22.6	22.9

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Table 3A-2(b) Lateral Wind Speed, $\hat{W}_y$, Ro $=10^6$

	0	10	20	30	40	50	60	70	80	90	100
0.150	-18.0	-20.4	-22.9	-25.6	-28.7	-32.0	-31.4	-30.7	-29.8	-28.9	-28.0
0.140	-17.4	-19.8	-22.3	-24.9	-28.0	-31.2	-30.6	-29.8	-28.9	-27.9	-27.0
0.130	-17.1	-19.4	-21.7	-24.2	-27.2	-30.4	-29.7	-28.9	-28.0	-27.0	-26.1
0.120	-17.0	-19.1	-21.2	-23.4	-26.3	-29.5	-28.8	-28.1	-27.1	-26.1	-25.2
0.110	-16.3	-18.4	-20.5	-22.6	-25.3	-28.3	-27.6	-26.7	-25.6	-24.6	-23.7
0.100	-15.5	-17.8	-19.9	-21.8	-24.3	-27.2	-26.2	-25.2	-24.0	-23.0	-22.1
0.090	-14.5	-17.1	-19.4	-20.9	-23.2	-25.9	-24.7	-23.5	-22.3	-21.3	-20.4
0.080	-13.5	-15.5	-17.4	-18.9	-20.9	-23.2	-22.3	-21.4	-20.4	-19.6	-18.8
0.070	-12.1	-13.5	-15.0	-16.5	-18.6	-21.1	-20.3	-19.3	-18.0	-17.2	-16.5
0.060	-10.4	-11.3	-12.4	-13.9	-16.4	-19.4	-18.4	-17.2	-15.2	-14.3	-13.9
0.050	-8.7	-9.8	-10.9	-12.0	-14.2	-17.0	-15.9	-14.7	-13.3	-12.3	-11.5
0.040	-7.0	-8.1	-9.2	-10.2	-12.1	-14.5	-13.3	-12.1	-10.9	-9.9	-9.0
0.030	-5.3	-6.2	-7.2	-8.4	-10.0	-11.6	-10.6	-9.4	-8.2	-7.2	-6.3
0.020	-3.7	-3.9	-4.4	-5.4	-7.1	-9.1	-7.9	-6.8	-5.8	-4.9	-4.0
0.010	-1.8	-1.8	-2.0	-2.5	-3.6	-4.6	-4.1	-3.4	-2.9	-2.4	-1.8
0.005	-0.8	-0.8	-0.9	-1.1	-1.6	-2.1	-1.8	-1.5	-1.3	-1.0	-0.8

	100	110	120	130	140	150	160	170	180	190	200
0.150	-28.0	-26.8	-25.8	-25.2	-24.2	-23.0	-21.8	-20.5	-19.1	-17.2	-15.0
0.140	-27.0	-25.8	-24.7	-24.2	-23.3	-22.2	-21.1	-19.8	-18.4	-16.5	-14.3
0.130	-26.1	-24.8	-23.8	-23.3	-22.4	-21.4	-20.2	-19.0	-17.6	-15.7	-13.6
0.120	-25.2	-23.9	-22.9	-22.4	-21.6	-20.5	-19.3	-18.0	-16.6	-14.8	-12.8
0.110	-23.7	-22.5	-21.5	-21.0	-20.0	-18.8	-17.9	-16.9	-15.6	-13.8	-11.8
0.100	-22.1	-21.0	-20.0	-19.6	-18.6	-17.3	-16.6	-15.8	-14.6	-13.0	-11.1
0.090	-20.4	-19.4	-18.5	-18.1	-17.1	-15.9	-15.3	-14.7	-13.8	-12.3	-10.5
0.080	-18.8	-17.8	-17.1	-16.7	-15.8	-14.6	-14.0	-13.3	-12.5	-11.2	-9.8
0.070	-16.5	-15.8	-15.3	-15.0	-14.2	-13.3	-12.7	-12.0	-11.3	-10.1	-8.7
0.060	-13.9	-13.5	-13.2	-13.0	-12.5	-11.9	-11.3	-10.7	-10.2	-8.9	-7.2
0.050	-11.5	-11.0	-10.7	-10.6	-10.5	-9.9	-9.7	-9.3	-8.6	-7.3	-5.6
0.040	-9.0	-8.4	-8.0	-8.1	-7.9	-7.7	-7.8	-7.6	-7.0	-5.7	-4.0
0.030	-6.3	-5.7	-5.2	-5.0	-5.0	-5.3	-5.6	-5.6	-5.5	-4.2	-2.4
0.020	-4.0	-3.1	-2.7	-3.1	-3.1	-3.0	-3.5	-3.8	-3.8	-2.8	-1.4
0.010	-1.8	-1.3	-1.0	-1.4	-1.4	-1.2	-1.6	-1.8	-1.9	-1.4	-0.6
0.005	-0.8	-0.6	-0.5	-0.6	-0.6	-0.5	-0.7	-0.8	-0.8	-0.6	-0.3
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3A-3(a) Longitudinal Wind Speed, $\hat{W}_x$, Ro $=10^5$

	0	10	20	30	40	50	60	70	80	90	100
0.150	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	60.0	62.2	64.3
0.140	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	60.0	62.2	64.3
0.130	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	60.0	62.2	64.3
0.120	30.5	35.0	39.7	44.6	48.6	51.9	54.6	57.3	60.0	62.2	64.3
0.110	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	60.0	62.2	64.3
0.100	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	60.0	62.1	64.0
0.090	30.5	35.0	39.7	44.8	48.6	51.9	54.6	57.3	59.9	61.8	63.4
0.080	30.5	35.0	39.7	44.8	48.6	51.9	54.4	56.7	58.8	60.5	62.0
0.070	30.5	35.0	39.7	44.6	48.4	51.2	53.5	55.6	57.5	59.1	60.6
0.060	30.4	34.8	39.5	44.6	47.7	49.9	51.9	54.0	56.0	57.7	59.2
0.050	28.4	32.4	36.8	41.6	45.1	47.8	49.9	51.9	54.0	55.7	57.2
0.040	26.4	30.2	34.4	39.1	42.5	45.4	47.5	49.4	51.2	52.5	53.6
0.030	24.4	28.2	32.3	36.7	39.8	42.3	44.3	45.9	47.0	47.9	48.5
0.020	22.3	26.2	30.0	33.4	34.7	34.9	35.3	35.5	35.6	36.8	38.5
0.010	17.6	20.0	22.3	24.3	24.7	24.4	24.3	24.2	24.2	25.0	26.4
0.005	14.2	15.4	16.6	17.7	18.0	18.0	18.1	18.3	18.4	18.9	19.7
0.001	11.5	11.8	12.1	12.4	12.6	12.9	13.2	13.5	13.8	14.0	14.3

	100	110	120	130	140	150	160	170	180	190	200
0.150	64.3	65.8	67.1	68.0	68.9	69.7	70.0	70.3	70.6	70.9	71.1
0.140	64.3	65.8	67.1	67.9	68.7	69.5	69.6	69.8	70.0	70.3	70.6
0.130	64.3	65.7	66.9	67.6	68.3	69.0	69.0	69.2	69.5	69.7	70.0
0.120	64.3	65.6	66.6	67.1	67.6	68.2	68.4	68.6	68.9	69.1	69.4
0.110	64.3	65.4	66.2	66.5	67.0	67.8	67.9	68.0	68.2	68.4	68.7
0.100	64.0	64.9	65.6	65.9	66.5	67.2	67.3	67.4	67.4	67.6	67.9
0.090	63.4	64.3	65.0	65.3	65.9	66.7	66.7	66.7	66.6	66.8	67.1
0.080	62.0	63.1	63.9	64.3	64.9	65.5	65.6	65.6	65.6	65.7	65.7
0.070	60.6	61.7	62.6	62.9	63.5	64.2	64.2	64.2	64.2	64.2	64.3
0.060	59.2	60.2	61.0	61.1	61.7	62.6	62.4	62.3	62.4	62.5	62.7
0.050	57.2	58.3	59.1	59.2	59.8	60.6	60.4	60.1	59.9	59.7	59.6
0.040	53.6	54.7	55.4	55.3	55.8	56.6	56.5	56.4	56.3	56.2	56.2
0.030	48.5	49.4	50.0	49.7	50.1	50.9	51.1	51.3	51.6	51.8	52.0
0.020	38.5	39.6	40.6	41.4	42.1	43.0	43.2	43.5	43.8	44.0	44.3
0.010	26.4	27.4	28.3	28.9	29.6	30.2	30.5	30.8	31.1	31.4	31.6
0.005	19.7	20.3	20.8	21.3	21.7	22.2	22.5	22.7	23.0	23.3	23.6
0.001	14.3	14.6	14.9	15.2	15.5	15.7	16.0	16.3	16.6	16.9	17.1

Table 3A-3(b) Lateral Wind Speed, $\hat{W}_y$, Ro $=10^5$

	0	10	20	30	40	50	60	70	80	90	100
0.150	-18.0	-20.4	-22.9	-25.6	-26.7	-32.0	-31.4	-30.7	-29.8	-26.9	-28.0
0.140	-17.4	-19.8	-22.3	-24.9	-26.0	-31.2	-30.6	-29.6	-28.9	-27.9	-27.0
0.130	-17.1	-19.4	-21.7	-24.2	-27.2	-30.4	-29.7	-28.9	-28.0	-27.0	-26.1
0.120	-17.0	-19.1	-21.2	-23.4	-26.3	-29.5	-28.8	-28.1	-27.1	-26.1	-25.2
0.110	-16.3	-18.4	-20.5	-22.6	-25.3	-28.3	-27.6	-26.7	-25.6	-24.6	-23.7
0.100	-15.5	-17.8	-19.9	-21.8	-24.3	-27.2	-26.2	-25.2	-24.0	-23.0	-22.1
0.090	-14.5	-17.1	-19.4	-20.9	-23.2	-25.9	-24.7	-23.5	-22.3	-21.3	-20.4
0.080	-13.5	-15.5	-17.4	-18.9	-20.9	-23.2	-22.3	-21.4	-20.4	-19.6	-18.8
0.070	-12.1	-13.5	-15.0	-16.5	-18.6	-21.1	-20.3	-19.3	-18.0	-17.2	-16.5
0.060	-10.4	-11.3	-12.4	-13.9	-16.4	-19.4	-18.4	-17.2	-15.2	-14.3	-13.9
0.050	-8.7	-9.8	-10.9	-12.0	-14.2	-17.0	-15.9	-14.7	-13.3	-12.3	-11.5
0.040	-7.0	-8.1	-9.2	-10.2	-12.1	-14.5	-13.3	-12.1	-10.9	-9.9	-9.0
0.030	-5.3	-6.2	-7.2	-8.4	-10.0	-11.8	-10.6	-9.4	-8.2	-7.2	-6.3
0.020	-3.7	-3.9	-4.4	-5.4	-7.1	-9.1	-7.9	-6.8	-5.8	-4.9	-4.0
0.010	-1.8	-1.8	-2.0	-2.5	-3.6	-4.8	-4.1	-3.4	-2.9	-2.4	-1.8
0.005	-0.8	-0.8	-0.9	-1.1	-1.6	-2.1	-1.8	-1.5	-1.3	-1.0	-0.8
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	100	110	120	130	140	150	160	170	180	190	200
0.150	-28.0	-26.8	-25.8	-25.2	-24.2	-23.0	-21.8	-20.5	-19.1	-17.2	-15.0
0.140	-27.0	-25.8	-24.7	-24.2	-23.3	-22.2	-21.1	-19.8	-18.4	-16.5	-14.3
0.130	-26.1	-24.8	-23.8	-23.3	-22.4	-21.4	-20.2	-19.0	-17.6	-15.7	-13.6
0.120	-25.2	-23.9	-22.9	-22.4	-21.6	-20.5	-19.3	-18.0	-16.6	-14.8	-12.8
0.110	-23.7	-22.5	-21.5	-21.0	-20.0	-18.8	-17.9	-16.9	-15.6	-13.8	-11.8
0.100	-22.1	-21.0	-20.0	-19.6	-18.6	-17.3	-16.6	-15.8	-14.6	-13.0	-11.1
0.090	-20.4	-19.4	-18.5	-18.1	-17.1	-15.9	-15.3	-14.7	-13.8	-12.3	-10.5
0.080	-18.8	-17.8	-17.1	-16.7	-15.8	-14.6	-14.0	-13.3	-12.5	-11.2	-9.8
0.070	-16.5	-15.8	-15.3	-15.0	-14.2	-13.3	-12.7	-12.0	-11.3	-10.1	-8.7
0.060	-13.9	-13.5	-13.2	-13.0	-12.5	-11.9	-11.3	-10.7	-10.2	-8.9	-7.2
0.050	-11.5	-11.0	-10.7	-10.8	-10.5	-9.9	-9.7	-9.3	-8.6	-7.3	-5.6
0.040	-9.0	-8.4	-8.0	-8.1	-7.9	-7.7	-7.8	-7.6	-7.0	-5.7	-4.0
0.030	-6.3	-5.7	-5.2	-5.0	-5.0	-5.3	-5.6	-5.8	-5.5	-4.2	-2.4
0.020	-4.0	-3.1	-2.7	-3.1	-3.1	-3.0	-3.5	-3.8	-3.8	-2.8	-1.4
0.010	-1.8	-1.3	-1.0	-1.4	-1.4	-1.2	-1.6	-1.8	-1.9	-1.4	-0.6
0.005	-0.8	-0.6	-0.5	-0.6	-0.6	-0.5	-0.7	-0.8	-0.8	-0.6	-0.3
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3A-4(a) Longitudinal Wind Speed, $\hat{W}_x$, Ro $=10^4$

	0	10	20	30	40	50	60	70	80	90	100
0.150	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.5	58.6
0.140	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.5	58.6
0.130	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.5	58.6
0.120	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.5	58.6
0.110	24.8	29.2	33.9	39.0	42.9	46.2	46.8	51.5	54.2	56.5	58.6
0.100	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.4	58.2
0.090	24.8	29.2	33.9	39.0	42.9	46.2	48.8	51.5	54.2	56.1	57.6
0.080	24.6	29.2	33.9	39.0	42.9	46.2	48.6	51.0	53.0	54.7	56.2
0.070	24.8	29.2	33.9	39.0	42.6	45.5	47.7	49.8	51.7	53.3	54.8
0.060	24.6	29.1	33.8	38.8	42.0	44.1	46.2	48.2	50.3	52.0	53.4
0.050	22.6	26.7	31.0	35.9	39.3	42.1	44.1	46.2	48.3	50.0	51.4
0.040	20.6	24.5	28.6	33.3	36.8	39.6	41.7	43.7	45.4	46.8	47.9
0.030	18.6	22.5	26.5	30.9	34.1	36.6	38.5	40.2	41.3	42.1	42.8
0.020	16.6	20.5	24.2	27.7	29.0	29.2	29.5	29.8	29.9	31.0	32.7
0.010	11.8	14.3	16.5	16.5	19.0	18.6	18.6	18.5	18.4	19.3	20.6
0.005	8.4	9.7	10.9	11.9	12.3	12.3	12.4	12.5	12.6	13.2	13.9
0.001	5.8	6.0	6.3	6.6	6.9	7.2	7.4	7.7	8.0	8.3	8.6

	100	110	120	130	140	150	160	170	180	190	200
0.150	58.6	60.0	61.3	62.2	63.1	64.0	64.3	64.5	64.8	65.1	65.4
0.140	58.6	60.0	61.3	62.1	62.9	63.7	63.8	64.0	64.3	64.6	64.8
0.130	58.6	60.0	61.2	61.8	62.5	63.2	63.3	63.4	63.7	64.0	64.3
0.120	58.6	59.9	60.9	61.3	61.9	62.5	62.6	62.8	63.1	63.4	63.7
0.110	58.6	59.6	60.4	60.7	61.3	62.0	62.1	62.2	62.4	62.6	62.9
0.100	58.2	59.2	59.9	60.1	60.7	61.5	61.5	61.6	61.7	61.9	62.2
0.090	57.6	58.5	59.2	59.6	60.2	60.9	60.9	60.9	60.9	61.1	61.3
0.080	56.2	57.3	58.2	58.6	59.2	59.8	59.9	59.9	59.9	59.9	60.0
0.070	54.8	56.0	56.8	57.2	57.7	58.4	58.4	58.4	58.4	58.5	58.5
0.060	53.4	54.5	55.2	55.4	56.0	56.9	56.7	56.5	56.6	56.8	56.9
0.050	51.4	52.6	53.4	53.5	54.0	54.8	54.6	54.4	54.1	54.0	53.9
0.040	47.9	49.0	49.6	49.6	50.1	50.8	50.6	50.7	50.5	50.4	50.4
0.030	42.8	43.7	44.2	43.9	44.4	45.1	45.4	45.6	45.8	46.0	46.3
0.020	32.7	34.0	35.1	35.6	36.4	37.2	37.5	37.8	38.0	38.3	38.5
0.010	20.6	21.7	22.5	23.2	23.6	24.5	24.8	25.0	25.3	25.6	25.9
0.005	13.9	14.5	15.1	15.5	16.0	16.4	16.7	17.0	17.3	17.5	17.8
0.001	8.6	8.8	9.1	9.4	9.7	10.0	10.3	10.5	10.8	11.1	11.4

Table 3A-4(b) Lateral Wind Speed, $\hat{W}_y$, Ro $=10^4$

	0	10	20	30	40	50	60	70	80	90	100
0.150	-18.0	-20.4	-22.9	-25.6	-28.7	-32.0	-31.4	-30.7	-29.8	-28.9	-28.0
0.140	-17.4	-19.8	-22.3	-24.9	-28.0	-31.2	-30.6	-29.8	-28.9	-27.9	-27.0
0.130	-17.1	-19.4	-21.7	-24.2	-27.2	-30.4	-29.7	-28.9	-28.0	-27.0	-26.1
0.120	-17.0	-19.1	-21.2	-23.4	-26.3	-29.5	-26.8	-28.1	-27.1	-26.1	-25.2
0.110	-16.3	-18.4	-20.5	-22.6	-25.3	-28.3	-27.6	-26.7	-25.6	-24.6	-23.7
0.100	-15.5	-17.8	-19.9	-21.8	-24.3	-27.2	-26.2	-25.2	-24.0	-23.0	-22.1
0.090	-14.5	-17.1	-19.4	-20.9	-23.2	-25.9	-24.7	-23.5	-22.3	-21.3	-20.4
0.080	-13.5	-15.5	-17.4	-18.9	-20.9	-23.2	-22.3	-21.4	-20.4	-19.6	-18.8
0.070	-12.1	-13.5	-15.0	-16.5	-18.6	-21.1	-20.3	-19.3	-18.0	-17.2	-16.5
0.060	-10.4	-11.3	-12.4	-13.9	-16.4	-19.4	-16.4	-17.2	-15.2	-14.3	-13.9
0.050	-8.7	-9.8	-10.9	-12.0	-14.2	-17.0	-15.9	-14.7	-13.3	-12.3	-11.5
0.040	-7.0	-8.1	-9.2	-10.2	-12.1	-14.5	-13.3	-12.1	-10.9	-9.9	-9.0
0.030	-5.3	-6.2	-7.2	-8.4	-10.0	-11.8	-10.6	-9.4	-8.2	-7.2	-6.3
0.020	-3.7	-3.9	-4.4	-5.4	-7.1	-9.1	-7.9	-6.8	-5.8	-4.9	-4.0
0.010	-1.8	-1.8	-2.0	-2.5	-3.6	-4.8	-4.1	-3.4	-2.9	-2.4	-1.8
0.005	-0.8	-0.6	-0.9	-1.1	-1.6	-2.1	-1.8	-1.5	-1.3	-1.0	-0.8
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	100	110	120	130	140	150	160	170	180	190	200
0.150	-28.0	-26.8	-25.8	-25.2	-24.2	-23.0	-21.8	-20.5	-19.1	-17.2	-15.0
0.140	-27.0	-25.8	-24.7	-24.2	-23.3	-22.2	-21.1	-19.8	-18.4	-16.5	-14.3
0.130	-26.1	-24.8	-23.8	-23.3	-22.4	-21.4	-20.2	-19.0	-17.6	-15.7	-13.6
0.120	-25.2	-23.9	-22.9	-22.4	-21.6	-20.5	-19.3	-18.0	-16.6	-14.8	-12.8
0.110	-23.7	-22.5	-21.5	-21.0	-20.0	-18.8	-17.9	-16.9	-15.6	-13.8	-11.8
0.100	-22.1	-21.0	-20.0	-19.6	-18.6	-17.3	-16.6	-15.8	-14.6	-13.0	-11.1
0.090	-20.4	-19.4	-18.5	-18.1	-17.1	-15.9	-15.3	-14.7	-13.8	-12.3	-10.5
0.080	-18.8	-17.8	-17.1	-16.7	-15.8	-14.6	-14.0	-13.3	-12.5	-11.2	-9.8
0.070	-16.5	-15.8	-15.3	-15.0	-14.2	-13.3	-12.7	-12.0	-11.3	-10.1	-8.7
0.060	-13.9	-13.5	-13.2	-13.0	-12.5	-11.9	-11.3	-10.7	-10.2	-8.9	-7.2
0.050	-11.5	-11.0	-10.7	-10.6	-10.5	-9.9	-9.7	-9.3	-8.6	-7.3	-5.6
0.040	-9.0	-8.4	-8.0	-8.1	-7.9	-7.7	-7.8	-7.6	-7.0	-5.7	-4.0
0.030	-6.3	-5.7	-5.2	-5.0	-5.0	-5.3	-5.6	-5.8	-5.5	-4.2	-2.4
0.020	-4.0	-3.1	-2.7	-3.1	-3.1	-3.0	-3.5	-3.8	-3.8	-2.8	-1.4
0.010	-1.8	-1.3	-1.0	-1.4	-1.4	-1.2	-1.6	-1.8	-1.9	-1.4	-0.6
0.005	-0.8	-0.6	-0.5	-0.6	-0.6	-0.5	-0.7	-0.8	-0.8	-0.6	-0.3
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3A-5(a) Longitudinal Wind Speed, $\hat{W}_x$, Ro $=10^3$

	0	10	20	30	40	50	60	70	80	90	100
0.150	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.7	52.8
0.140	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.7	52.8
0.130	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.7	52.8
0.120	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.7	52.8
0.110	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.7	52.8
0.100	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.8	48.4	50.6	52.5
0.090	19.0	23.5	28.2	33.2	37.1	40.4	43.1	45.7	48.4	50.3	51.9
0.080	19.0	23.5	28.2	33.2	37.1	40.4	42.9	45.2	47.3	48.9	50.4
0.070	19.0	23.5	28.2	33.2	36.8	39.7	42.0	44.1	46.0	47.6	49.1
0.060	18.9	23.3	28.0	33.1	36.2	38.4	40.4	42.4	44.5	46.2	47.7
0.050	16.9	20.9	25.2	30.1	33.6	36.3	38.4	40.4	42.5	44.2	45.7
0.040	14.9	18.7	22.9	27.5	31.0	33.9	36.0	37.9	39.7	41.0	42.1
0.030	12.8	16.7	20.8	25.2	28.3	30.8	32.8	34.4	35.5	36.3	37.0
0.020	10.8	14.7	18.5	21.9	23.2	23.4	23.8	24.0	24.1	25.3	26.9
0.010	6.0	8.5	10.8	12.8	13.2	12.9	12.8	12.7	12.6	13.5	14.9
0.005	2.7	3.9	5.1	6.1	6.5	6.5	6.6	6.7	6.9	7.4	8.2
0.001	0.0	0.3	0.6	0.8	1.1	1.4	1.7	2.0	2.2	2.5	2.8

	100	110	120	130	140	150	160	170	180	190	200
0.150	52.8	54.3	55.6	56.5	57.3	58.2	58.5	58.8	59.1	59.3	59.6
0.140	52.8	54.3	55.5	56.3	57.1	58.0	58.1	58.2	58.5	58.8	59.1
0.130	52.8	54.2	55.4	56.1	56.7	57.4	57.5	57.7	58.0	58.2	58.5
0.120	52.8	54.1	55.1	55.6	56.1	56.7	56.9	57.1	57.3	57.6	57.9
0.110	52.8	53.9	54.7	55.0	55.5	56.2	56.4	56.5	56.7	56.9	57.2
0.100	52.5	53.4	54.1	54.4	55.0	55.7	55.8	55.9	55.9	56.1	56.4
0.090	51.9	52.7	53.5	53.8	54.4	55.2	55.2	55.1	55.1	55.3	55.6
0.080	50.4	51.5	52.4	52.8	53.4	54.0	54.1	54.1	54.1	54.2	54.2
0.070	49.1	50.2	51.1	51.4	52.0	52.7	52.7	52.7	52.7	52.7	52.8
0.060	47.7	48.7	49.5	49.6	50.2	51.1	50.9	50.8	50.9	51.0	51.1
0.050	45.7	46.8	47.6	47.7	48.3	49.1	48.8	48.6	48.4	48.2	48.1
0.040	42.1	43.2	43.9	43.8	44.3	45.1	45.0	44.9	44.8	44.7	44.6
0.030	37.0	37.9	38.4	38.2	38.6	39.4	39.6	39.8	40.1	40.3	40.5
0.020	26.9	28.3	29.3	29.9	30.6	31.5	31.7	32.0	32.3	32.5	32.8
0.010	14.9	15.9	16.6	17.4	18.1	18.7	19.0	19.3	19.6	19.8	20.1
0.005	8.2	8.8	9.3	9.6	10.2	10.7	10.9	11.2	11.5	11.8	12.1
0.001	2.8	3.1	3.4	3.7	3.9	4.2	4.5	4.8	5.1	5.3	5.6

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Table 3A-5(b) Lateral Wind Speed, $\hat{W}_y$, Ro $=10^3$

	0	10	20	30	40	50	60	70	80	90	100
0.150	-18.0	-20.4	-22.9	-25.6	-28.7	-32.0	-31.4	-30.7	-29.8	-28.9	-28.0
0.140	-17.4	-19.8	-22.3	-24.9	-28.0	-31.2	-30.6	-29.8	-28.9	-27.9	-27.0
0.130	-17.1	-19.4	-21.7	-24.2	-27.2	-30.4	-29.7	-28.9	-28.0	-27.0	-26.1
0.120	-17.0	-19.1	-21.2	-23.4	-26.3	-29.5	-28.8	-26.1	-27.1	-26.1	-25.2
0.110	-16.3	-18.4	-20.5	-22.6	-25.3	-28.3	-27.6	-26.7	-25.6	-24.6	-23.7
0.100	-15.5	-17.8	-19.9	-21.8	-24.3	-27.2	-26.2	-25.2	-24.0	-23.0	-22.1
0.090	-14.5	-17.1	-19.4	-20.9	-23.2	-25.9	-24.7	-23.5	-22.3	-21.3	-20.4
0.080	-13.5	-15.5	-17.4	-18.9	-20.9	-23.2	-22.3	-21.4	-20.4	-19.6	-18.8
0.070	-12.1	-13.5	-15.0	-16.5	-18.6	-21.1	-20.3	-19.3	-18.0	-17.2	-16.5
0.060	-10.4	-11.3	-12.4	-13.9	-16.4	-19.4	-18.4	-17.2	-15.2	-14.3	-13.9
0.050	-8.7	-9.6	-10.9	-12.0	-14.2	-17.0	-15.9	-14.7	-13.3	-12.3	-11.5
0.040	-7.0	-8.1	-9.2	-10.2	-12.1	-14.5	-13.3	-12.1	-10.9	-9.9	-9.0
0.030	-5.3	-6.2	-7.2	-8.4	-10.0	-11.6	-10.6	-9.4	-8.2	-7.2	-6.3
0.020	-3.7	-3.9	-4.4	-5.4	-7.1	-9.1	-7.9	-6.8	-5.8	-4.9	-4.0
0.010	-1.8	-1.8	-2.0	-2.5	-3.6	-4.8	-4.1	-3.4	-2.9	-2.4	-1.8
0.005	-0.8	-0.8	-0.9	-1.1	-1.6	-2.1	-1.8	-1.5	-1.3	-1.0	-0.8
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	100	110	120	130	140	150	160	170	180	190	200
0.150	-28.0	-26.8	-25.8	-25.2	-24.2	-23.0	-21.8	-20.5	-19.1	-17.2	-15.0
0.140	-27.0	-25.8	-24.7	-24.2	-23.3	-22.2	-21.1	-19.8	-18.4	-16.5	-14.3
0.130	-26.1	-24.8	-23.8	-23.3	-22.4	-21.4	-20.2	-19.0	-17.6	-15.7	-13.6
0.120	-25.2	-23.9	-22.9	-22.4	-21.6	-20.5	-19.3	-18.0	-16.6	-14.8	-12.8
0.110	-23.7	-22.5	-21.5	-21.0	-20.0	-18.8	-17.9	-16.9	-15.6	-13.8	-11.8
0.100	-22.1	-21.0	-20.0	-19.6	-18.6	-17.3	-16.6	-15.8	-14.6	-13.0	-11.1
0.090	-20.4	-19.4	-18.5	-18.1	-17.1	-15.9	-15.3	-14.7	-13.8	-12.3	-10.5
0.080	-18.8	-17.8	-17.1	-16.7	-15.6	-14.6	-14.0	-13.3	-12.5	-11.2	-9.8
0.070	-16.5	-15.8	-15.3	-15.0	-14.2	-13.3	-12.7	-12.0	-11.3	-10.1	-8.7
0.060	-13.9	-13.5	-13.2	-13.0	-12.5	-11.9	-11.3	-10.7	-10.2	-8.9	-7.2
0.050	-11.5	-11.0	-10.7	-10.6	-10.5	-9.9	-9.7	-9.3	-8.6	-7.3	-5.6
0.040	-9.0	-8.4	-8.0	-8.1	-7.9	-7.7	-7.8	-7.6	-7.0	-5.7	-4.0
0.030	-6.3	-5.7	-5.2	-5.0	-5.0	-5.3	-5.6	-5.8	-5.5	-4.2	-2.4
0.020	-4.0	-3.1	-2.7	-3.1	-3.1	-3.0	-3.5	-3.8	-3.8	-2.8	-1.4
0.010	-1.8	-1.3	-1.0	-1.4	-1.4	-1.2	-1.6	-1.8	-1.9	-1.4	-0.6
0.005	-0.8	-0.6	-0.5	-0.6	-0.6	-0.5	-0.7	-0.8	-0.8	-0.6	-0.3
0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX 3B

GRAPHICAL ILLUSTRATION OF STABLE AND NEUTRAL BOUNDARY LAYER WIND SPEED PROFILES

To provide an illustration of the velocity profiles which can be encountered along a flight path during approach through neutral and stable boundary layers, seven velocity profiles have been computed using the model developed in this report. Both longitudinal and lateral wind speeds are shown. The conditions for which the velocity profiles have been computed are shown in Figure 3B-1 along with wind speed profiles calculated from the standard log-linear equation for the stable boundary layer, see References [3-2 and 3-5]. This enables a comparison of the simpler theoretical models with the more elaborate simulation models developed in this report to be made. One thing to note in comparing the velocity profiles is that the log-linear, theoretical models give only the longitudinal component of wind speed, whereas, the table lookup model provides both the longitudinal and the lateral components. The lateral wind speed component is quite significant in many of the cases illustrated and represents an estimate of the directional shear encountered during approach or landing. This directional shear cannot be obtained from the simpler theoretical equations.

Figures 3B-2 and 3B-5 through 3B-7 are computed for a u_* value of 0.1 m s^{-1}. This value of friction velocity when used to compute dimensional height from the nondimensional form $\hat{z}$ gives a value of $z = 173$ m at $\hat{z} = 0.15$ which is the maximum vertical extension of the tabulated data. Consequently, the aforementioned figures do not extend to the 500 m level as do Figures 3B-1, 3B-3 and 3B-4.

Additional visualization of the velocity profiles which can be encountered in stable and neutral boundary layers with turbulence superimposed are given in the text, Figures 3-8 through 3-13, Section 3.4.

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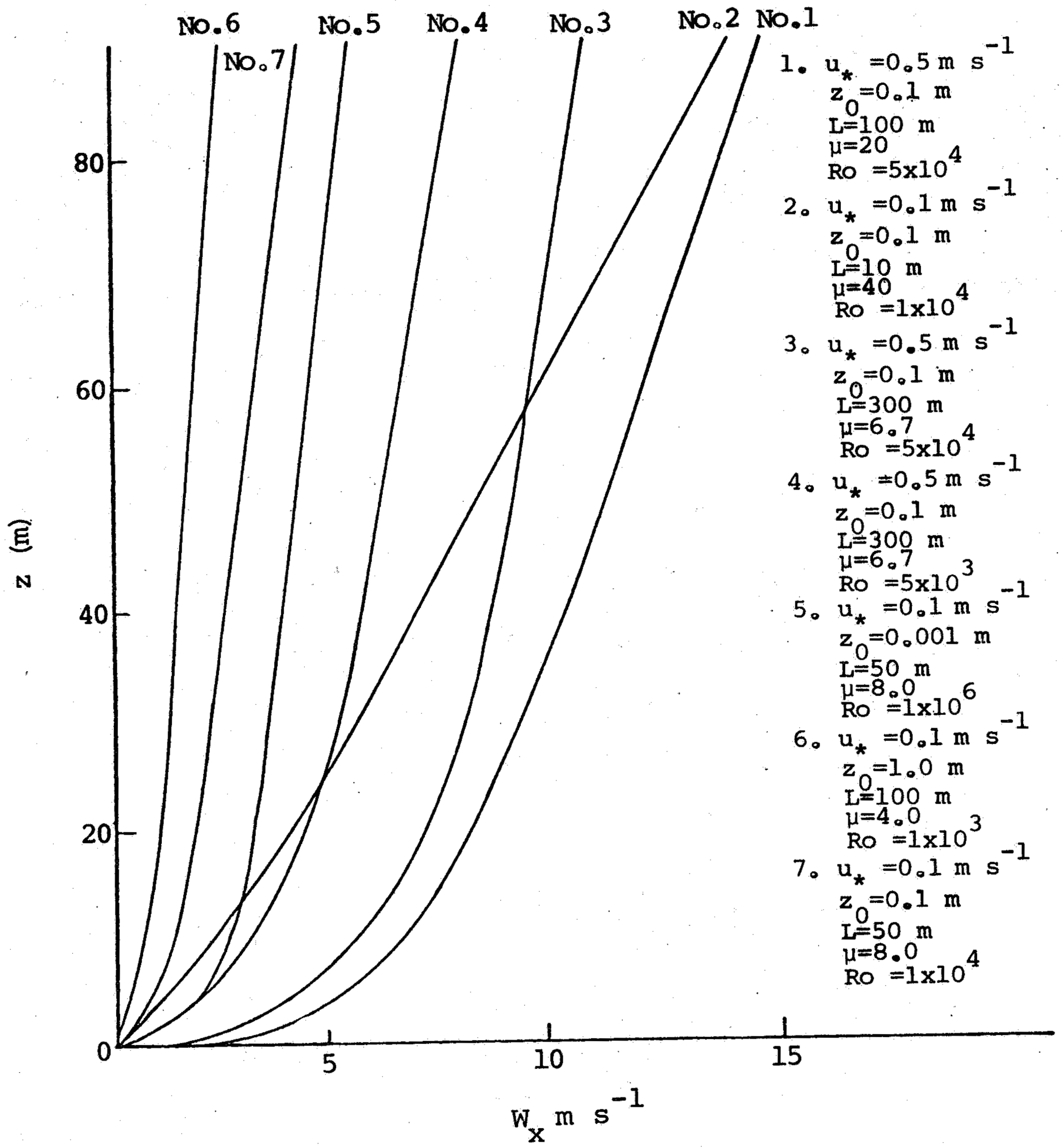

Figure 3B-1 Theoretical Wind Speed Profile for Comparison with Figures 3B-2 through 3B-8 Computed with Wind Shear Model

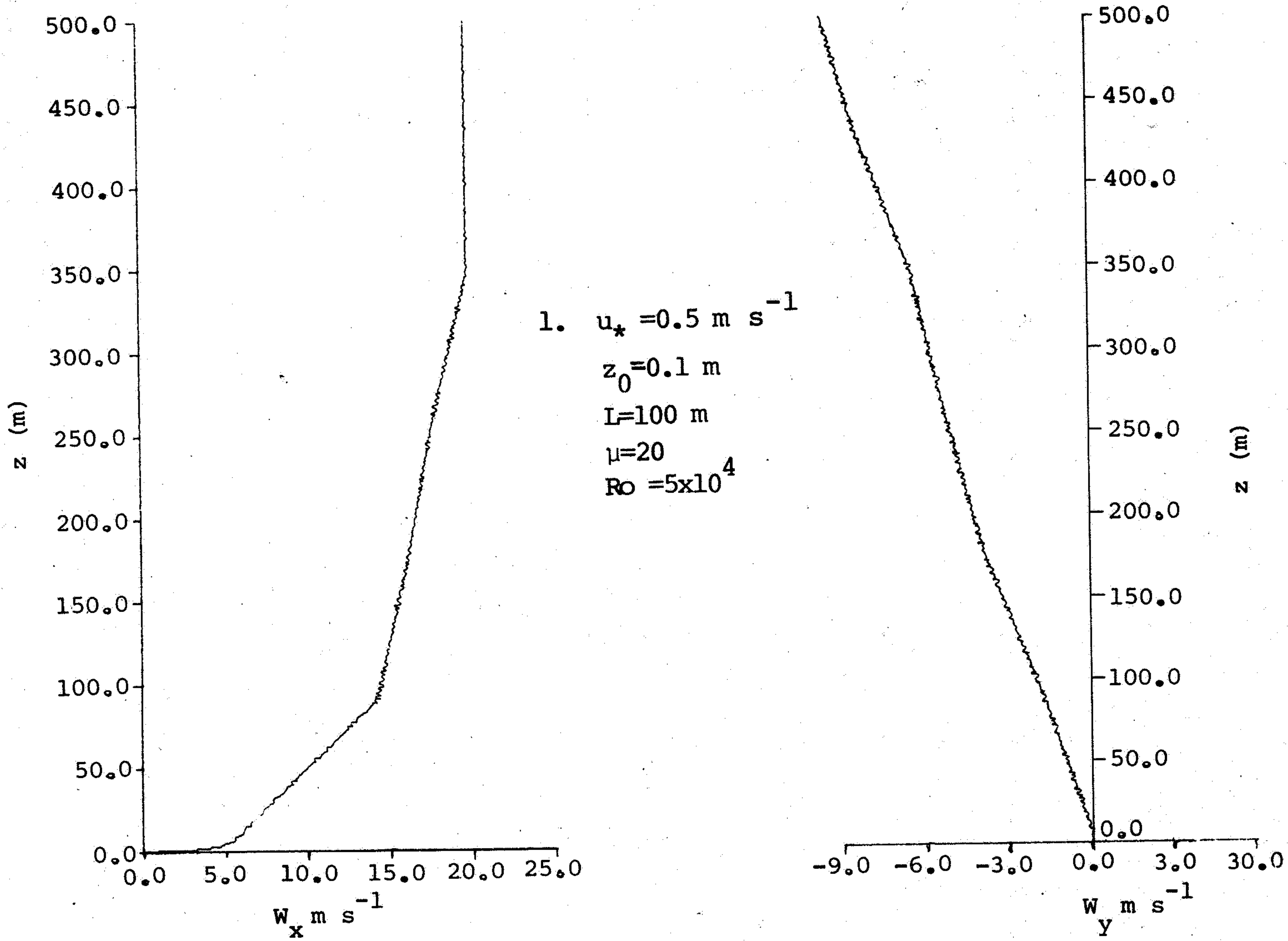

Figure 3B-2 Stable Boundary Layer

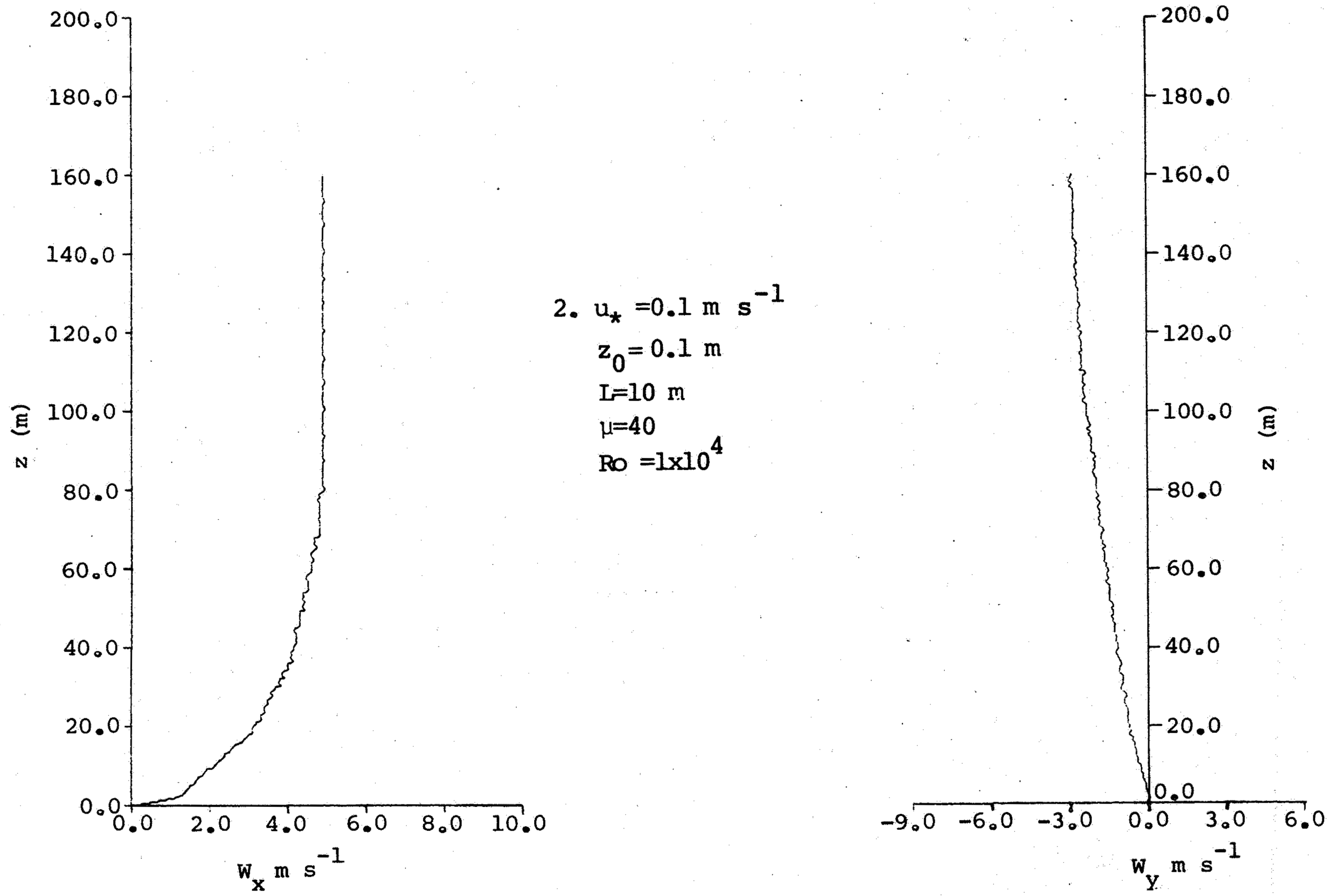

Figure 3B-3 Stable Boundary Layer

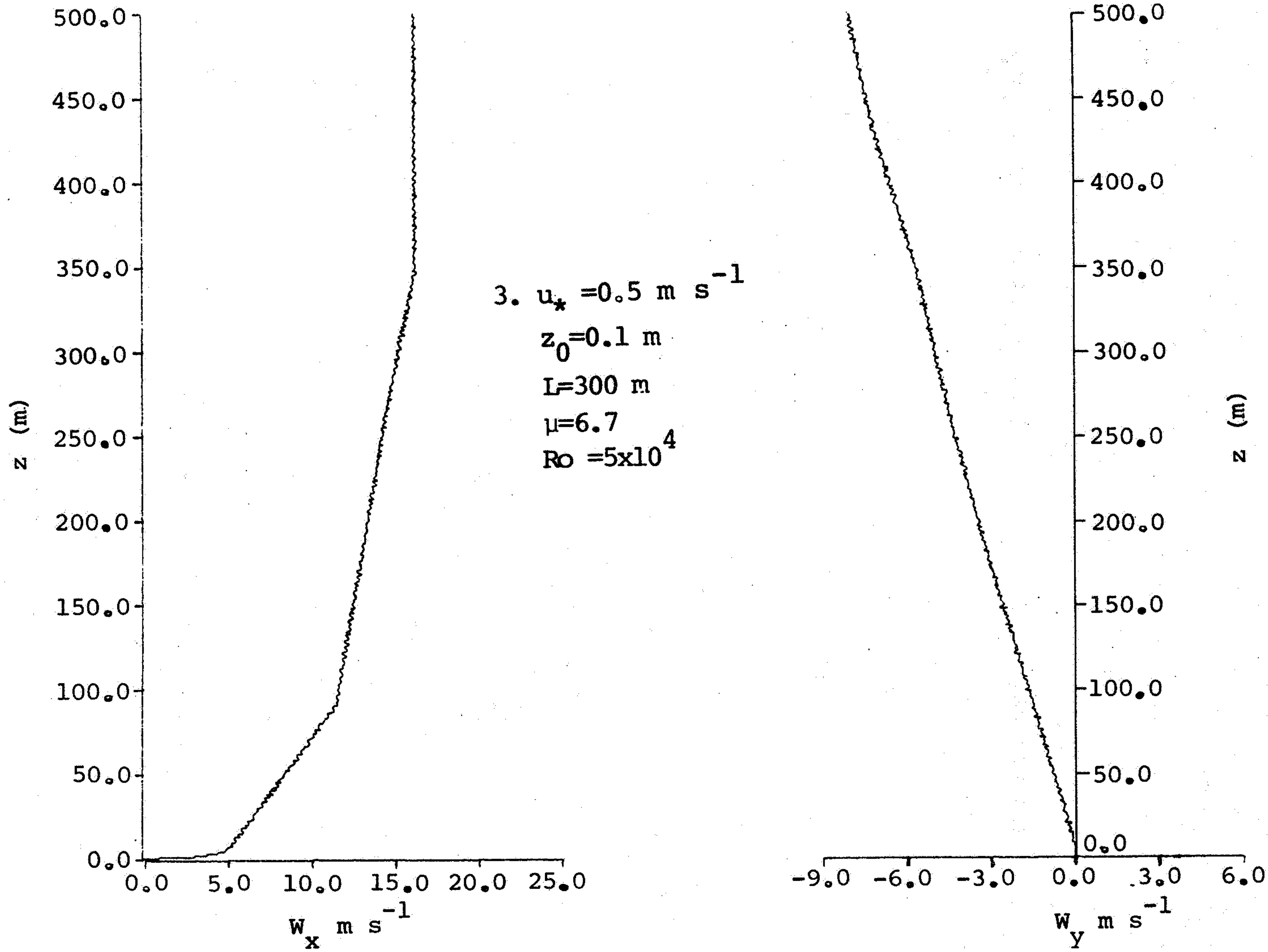

Figure 3B-4 Stable Boundary Layer

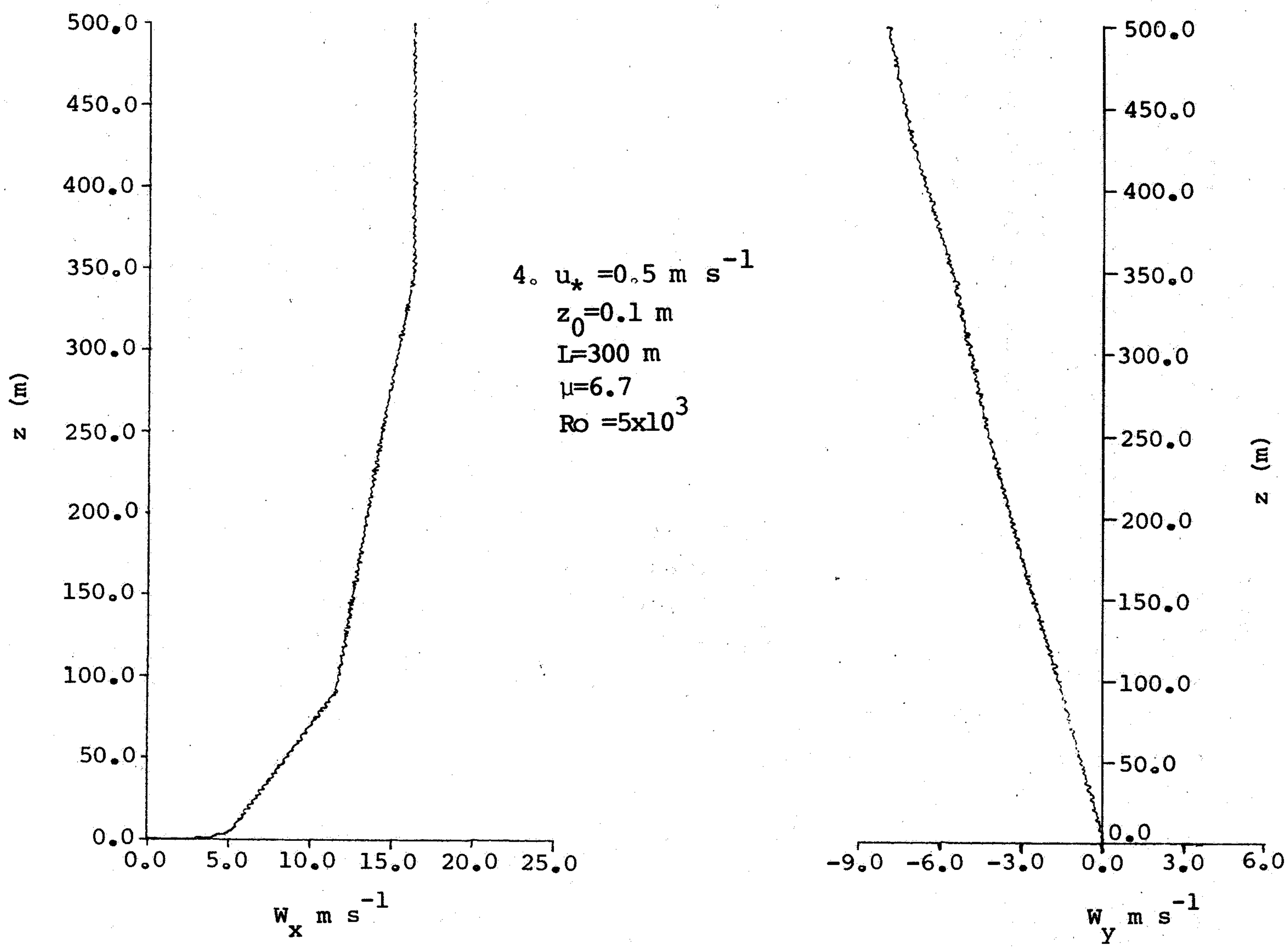

Figure 3B-5 Stable Boundary Layer

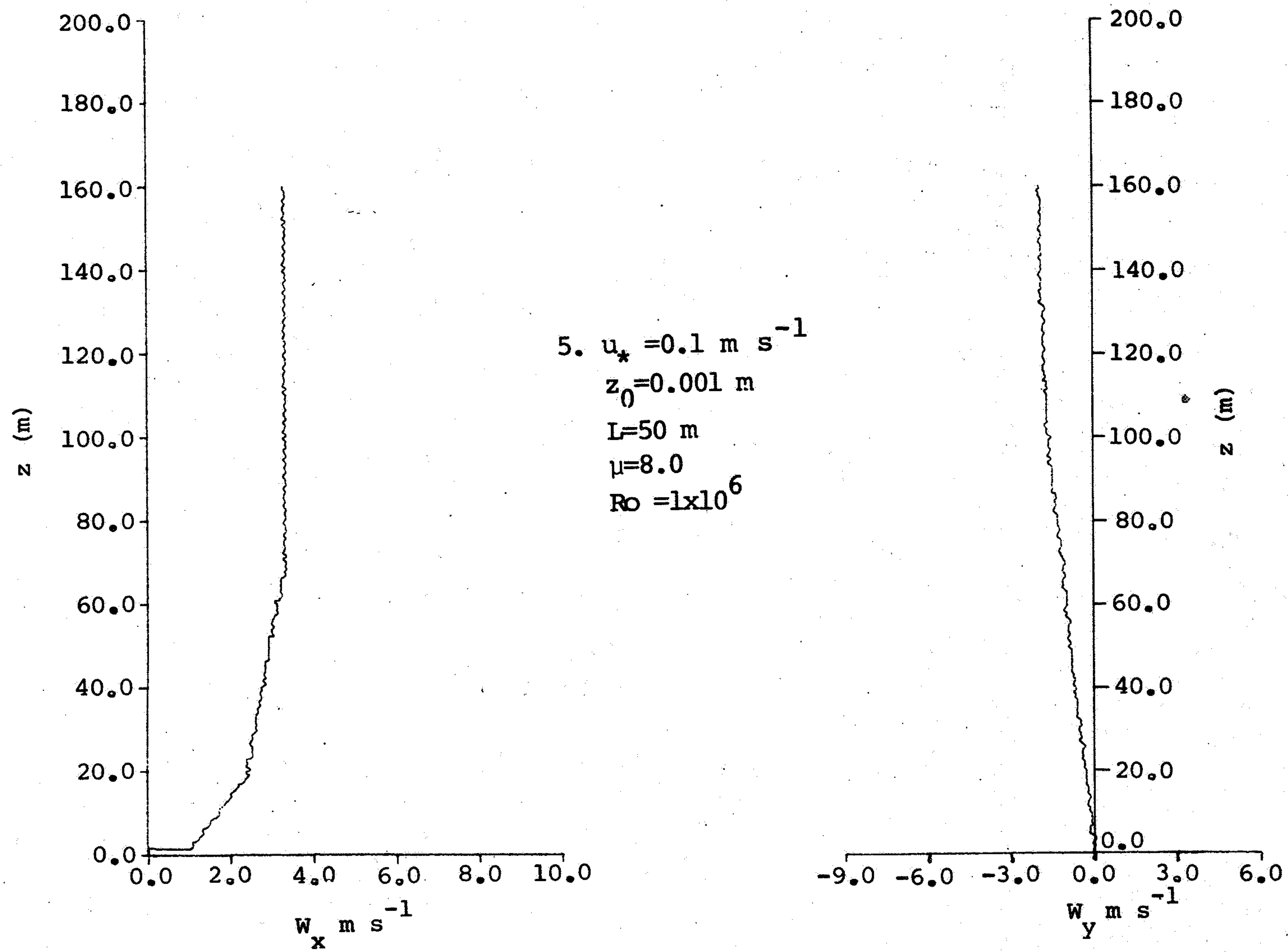

Figure 3B-6 Stable Boundary Layer

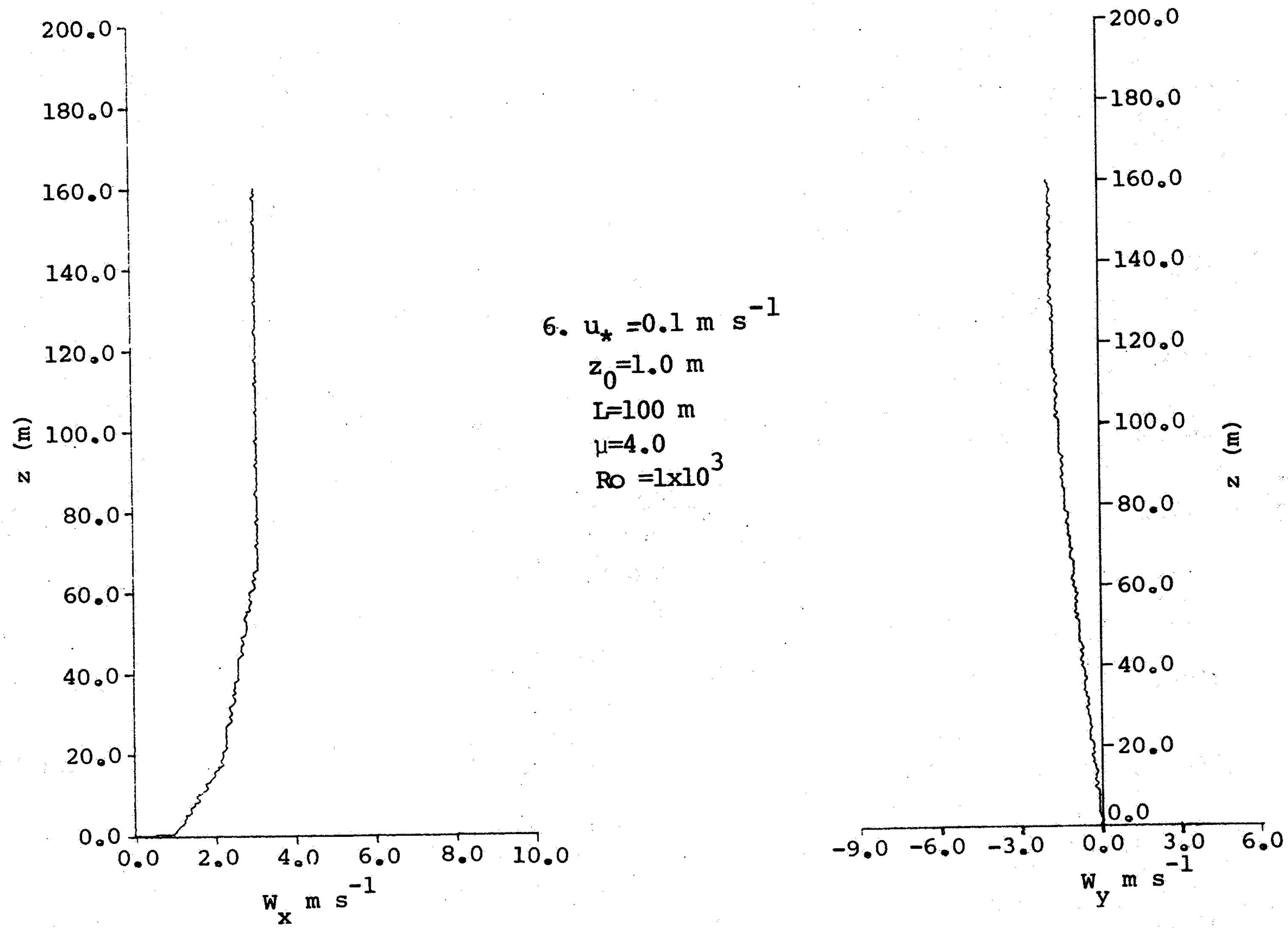

Figure 3B-7 Stable Boundary Layer

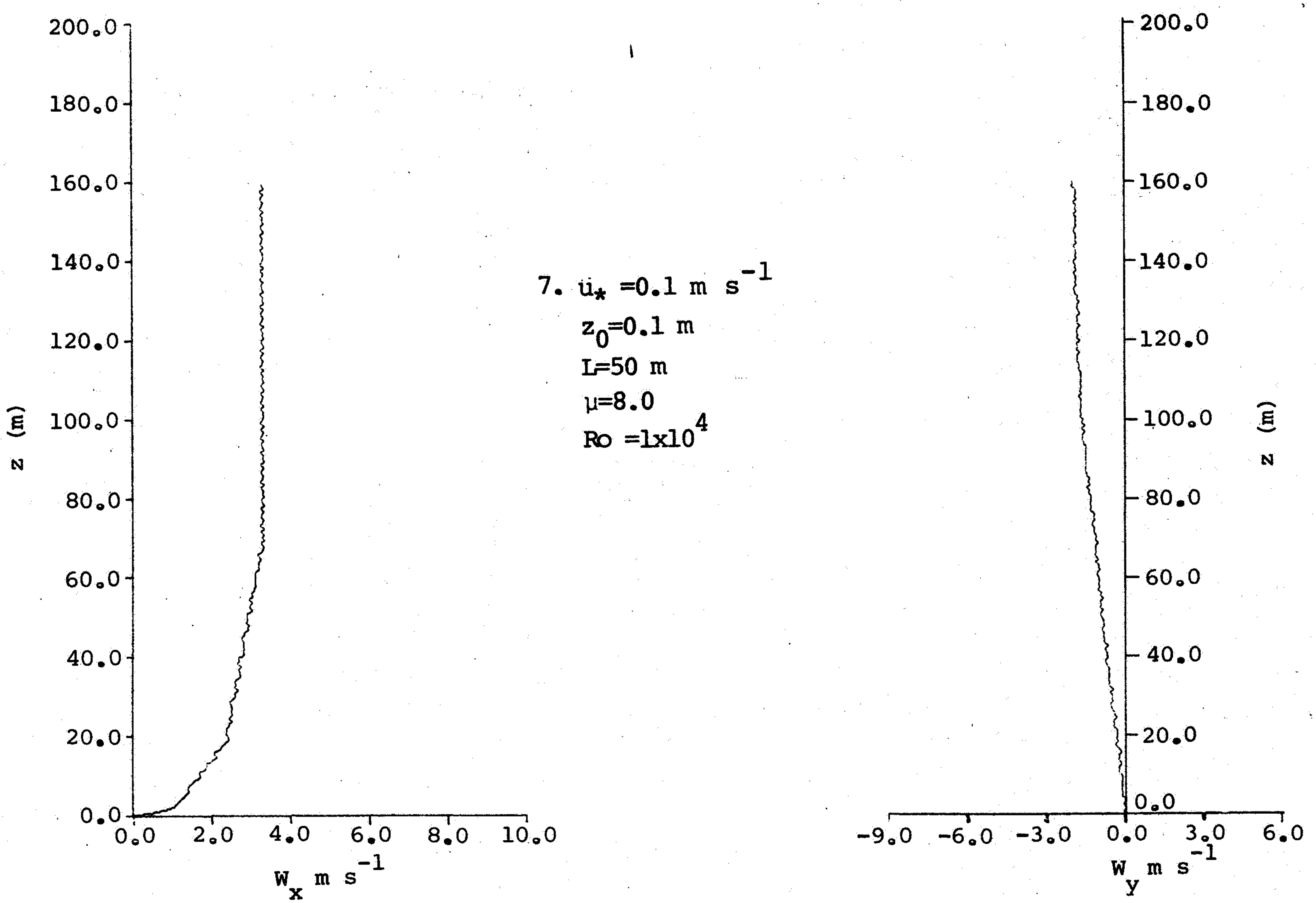

Figure 3B-8 Stable Boundary Layer

APPENDIX 3C

COMPUTER PROGRAM

The subroutine STB is a FORTRAN computer program for calculating the wind speeds W_x and W_y and the wind speed gradients $\partial W_x/\partial z$ and $\partial W_y/\partial z$. Inputs to the program are height, z, friction velocity, u_*, Coriolis parameter, f, stability parameter, μ, and surface roughness, z_o. These parameters must be introduced in units of meters and meters per second, respectively. The returned velocities and gradients have units of meters per second and inverse seconds, respectively. Wind speeds and gradients at a new value of height, z, are obtained by simply assigning a new value to z in the calling program. A new condition of stability is also achieved by assigning μ a new value in the calling program.

The user has the option of adding turbulent fluctuations to the wind speed by assigning the control integer NKK a value greater than two.

Subroutine STB

The subroutine STB for a given height z and with the parameter, μ, specified provides the wind velocity W_x and W_y. The user has the option of superimposing turbulence fluctuations on the mean wind speed if desired. The turbulence simulation routine uses the spectra developed in Section 3.5 and the z-transformation technique for generating the fluctuations w_x, w_y and w_z.

Subroutine STB first calls the subroutine INIT, which reads the input data into storage. The control variable NST is then set equal to two and further use of STB does not call the subroutine INIT. STB then calls the subroutine WINDF which interpolates wind speeds in the z direction for a prescribed value of μ.

At the user's option, NKK (0<NKK) can be set greater than two and the subroutine STB will call the subroutine DRYDEN which processes the random signal from the subroutine GAUSS and generates turbulent fluctuations having the modified Dryden spectra described in Section 3.4. These fluctuations are added to the turbulent wind field output.

Nomenclature

Subroutine STB(Z,AMU,USTR,F,ZO,NST,WX,WY,DWX,DWY,DT,IX,NKK)

Z	Height (m)	[INPUT]
AMU	Stability parameter ($-333.33 < \mu < 216.67$)	[INPUT]
USTR	Surface friction velocity u_* (m s^{-1})	[INPUT]
F	Coriolis parameter, f (s^{-1})	[INPUT]
ZO	Surface roughness, z_o (m)	[INPUT]
NST	Control variable NST = 1 initiates the storage of the tabulated wind speeds	[INPUT]
WX	Wind speed in the x direction (m s^{-1})	[OUTPUT]
WY	Wind speed in the y direction (m s^{-1})	[OUTPUT]
DWX	Gradient of W_x in the z direction (s^{-1})	[OUTPUT]
DWY	Gradient of W_y in the z direction (s^{-1})	[OUTPUT]
DT	Time increment Δt of the turbulent fluctuation (s)	[INPUT]
IX	Initiating integer for random signal generator, value arbitrary	[INPUT]
NKK	Integer for total terms of z transformation (if NKK ≤ 2 turbulence is not added if NKK > 2 turbulence is superimposed on wind speed outputs)	[INPUT]

Listing of Subroutine STB

```
      SUBROUTINE STB(ZP,AMU,USTR,F,ZO,NST,WX,WY,DWX,DWY,DT,IX,NKK)
      COMMON/WIND/WDEL(34,11,2),IMU,IMUM,AMUU(34),DW(34,11,2),
     SWXR(34),WYR(34),RAMJ,ALFA,UREF,VREF,UDEF
      COMMON/ST/AL
      IF(NST.NE.1) GO TO 100
      IX=65549
      CALL INIT
      RUSTR=USTR/(F*ZO)
      NST=2
100   CONTINUE
      Z=ZP+ZO
      CALL WINDF(AMU,Z,WX,WY,DWX,DWY,USTR,F,RUSTR,IZ)
      IF(NKK-2) 141,141,151
141   DU=0.
      DV=0.
      GO TO 161
151   CALL DRYDEN(Z,AMU,USTR,F,WX,DU,DV,DW,DT,IX,NKK)
161   WX=WX+DU
      WY=WY+DV
      RETURN
      END
```

Subroutine DRYDEN

The subroutine DRYDEN first calls the subroutine GAUSS which generates a Gaussian white noise random signal. The random signal is then passed through a filter which generates the fluctuating output having a spectrum function of the Dryden form which fits the data of Kaimal [3-3]. The subroutine DRYDEN then returns the fluctuating wind components, DU, DV and DW to the subroutine STB.

The subroutine DRYDEN utilizes the stability parameter, μ, the friction velocity, u_*, the Coriolis parameter, f, and the wind speed at height, z. The scale frequencies, n_0, and turbulence intensities, σ^2, are computed internally in the subroutine.

Nomenclature

Subroutine DRYDEN(Z,SMU,USTR,F,V,DU,DV,DW,DT,IX,NKK)

Z	Height (m)	[INPUT]
SMU	Stability parameter, μ	[INPUT]
USTR	Friction velocity, u_* (m s^{-1})	[INPUT]
F	Coriolis parameter, f (s^{-1})	[INPUT]
DU	Wind fluctuation in longitudinal direction (m s^{-1})	[INPUT]
DV	Wind fluctuation in lateral direction (m s^{-1})	[OUTPUT]
DW	Wind fluctuation in vertical direction (m s^{-1})	[OUTPUT]
DT	Time increment of the turbulent fluctuations (s)	[INPUT]
IX	Starting integer for generating random signal	[SPACE]
NKK	Total number of terms for z transform	[INPUT]

Listing of Subroutine DRYDEN

```
      SUBROUTINE DRYDEN(Z,SMU,USTR,F,V,DU,DV,DW,T,IX,NKK)
      DIMENSION X(10),Y(10),FO(3),SIG(3),AK(3),AC(3)
      COMMON/ST/AL
      ZAL=Z/AL
      RI=ZAL/(1.+4.5*ZAL)
      IF(RI-0.0288)81,81,82
   81 FO(1)=0.014
      GO TO 83
   82 FO(1)=0.5*RI
   83 IF(RI-0.0176) 84,84,85
   84 FO(2)=0.0265
```

```
      GO TO 86
   85 FO(2)=1.5*RI
   86 IF(RI-0.0343) 87,87,88
   87 FO(3)=0.0962
      GO TO 89
   88 FO(3)=2.8*RI
   89 IF(ZAL-1.) 95,96,96
   96 IF(ZAL-1.22) 97,94,94
   94 SIG(3)=0.
      GO TO 98
   95 SIG(3)=1.3-0.13*ZAL**0.5
      GO TO 98
   97 SIG(3)=6.49-5.32*ZAL
   98 SIG(2)=SIG(3)/(0.177+0.00277*Z)**0.4
      SIG(1)=SIG(3)/(0.583+0.00139*Z)**0.8
      DO 99 KK=1,3
      AK(KK)=85.78*V*FO(KK)*SIG(KK)*SIG(KK)/Z
      AC(KK)=23.85*V*FO(KK)/Z
   99 CONTINUE
      NBB=1
  100 DO 130 I=1,NKK
      CALL GAUSS(IX,1.,0.,R)
      X(I)=R
  130 CONTINUE
      Y(1)=0.
      C=EXP(-AC(NBB)*T)
      D=(SQRT(AK(NBB)))*(1.-C)/AC(NBB)
      DO 141 I=2,NKK
      Y(I)=C*Y(I-1)+D*X(I-1)
  141 CONTINUE
      IF(NBB-2) 142,143,144
  142 DU=Y(NKK)
      GO TO 145
  143 DV=Y(NKK)
      GO TO 145
  144 DW=Y(NKK)
  145 CONTINUE
      NBB=NBB+1
      IF(NBB.LE.3) GO TO 100
      RETURN
      END
```

Subroutine GAUSS

The subroutine GAUSS is called by the subroutine DRYDEN. Each time GAUSS is called it generates a new random number. Random numbers generated by GAUSS are white noise having a Gaussian distribution.

Nomenclature

Subroutine GAUSS (IX,S,AM,V)

IX	Arbitrary starting number, IX = 65549	[INPUT] [OUTPUT]
S	Adjusting number, setting S = 1.0 gives standard deviation of unity	[INPUT]
AM	Adjusting number, setting AM = 0.0 gives zero mean	[INPUT]
V	Random number output	[OUTPUT]

Listing of Subroutine GAUSS

```
      SUBROUTINE GAUSS(IX,S,AM,V)
      REAL*8 Y
      A=0.0
      DO 50 I=1,12
      IY=IX*65539
      IF(IY)5,6,6
    5 IY=IY+2147483647+1
    6 Y=IY
      Y=Y*0.4656613D-9
      IX=IY
   50 A=A+Y
      V=(A-6.0)*S+AM
      RETURN
      END
```


Subroutine INIT

The subroutine INIT is called once by the subroutine STB to initiate storage of the data. Subroutine INIT stores the data according to the grid system arrangement shown in Figure 3C-1. The data are stored as WDEL (I,J,K) where each row designated by J corresponds to the wind difference at that elevation as explained in Section 3.1. Each column designated by I represents a prescribed value of μ ranging from -333.34 to 216.67. The index K=1 represents longitudinal wind speed and K=2 represents lateral wind speed. The stored data is transferred to the subroutine WINDF through a common statement.

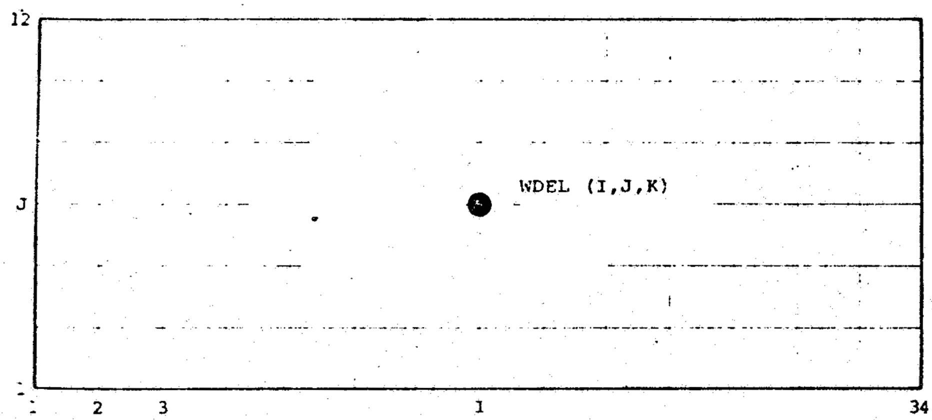

Figure 3C-1 Grid System: K=1 Corresponds to $\Delta\hat{W}_x = \hat{W}_x(\hat{z} = 0.15) - W_x(\hat{z})$ and K=2 Corresponds to $\hat{W}_y = \hat{W}_y(\hat{z}) - \hat{W}_y(\hat{z} = 0.15)$

Listing of Subroutine INIT

```
      SUBROUTINE INIT
      COMMON/WIND/WDEL(34,11,2),IMU,IMUM,AMUU(34),DW(34,11,2),
     $WXR(34),WYR(34),RAMU,ALFA,UREF,VREF,UDEF
  200 FORMAT(8F10.4)
  400 FORMAT(11F5.2)
C**************     FEED IN INITIAL DATA MU
      READ(5,200) (AMUU(I),I=1,34)
C**************     FEED IN DATA WDEL
      DO 3 K=1,2
      DO 3 I=1,34
    3 READ(5,400) (WDEL(I,J,K),J=1,11)
C**************     FEED IN DATA DWX/DZ AND DWY/DZ
      ZMAX=0.15
      ZMIN=0.001
      DZ=(ZMAX-ZMIN)/10.
      DO 2 K=1,2
      DO 2 I=1,34
      DW(I,11,K)=(WDEL(I,11,K)-WDEL(I,10,K))/DZ
      DW(I,1,K)=(WDEL(I,2,K)-WDEL(I,1,K))/DZ
      DO 2 J=2,10
      DW(I,J,K)=(WDEL(I,J+1,K)-WDEL(I,J-1,K))/DZ/2.
    2 CONTINUE
      RAMU=-400.
      ALFA=1.0
    1 RETURN
      END
```

Subroutine WINDF

The WINDF subroutine is called by the subroutine STB for values of μ and z. Interpolation is performed by an area-weighting method for the velocity at the elevation and for the stability condition, μ, from the tabulated data placed in storage by subroutine INIT. The area-weighting interpolation method is illustrated in Figure 3C-2.

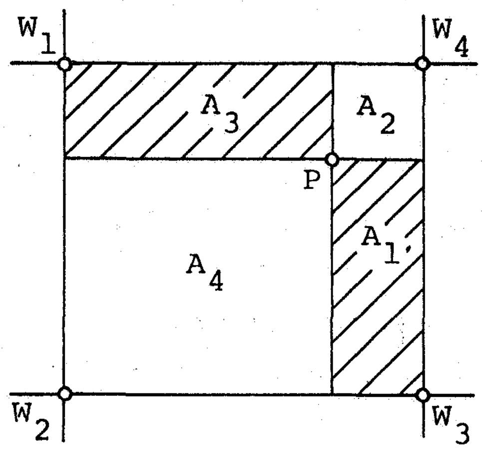

Figure 3C-2 Area-Weighting Technique

The area-weighting scheme calculates the velocity and velocity gradient at the specified point by using the four nearest neighboring grid point values. The velocity at point P is given by:

$$W_p = \frac{1}{A}[A_1W_1 + A_2W_2 + A_3W_3 + A_4W_4]$$

where

$$A = A_1 + A_2 + A_3 + A_4$$

The same interpolation method is used for the velocity gradients.

Nomenclature

Subroutine WINDF(AMU,Z,WX,WY,DWX,DWY,USTR,F,ROSTR)

AMU Atmospheric stability parameter, μ [INPUT]

Z	Height (m)	[INPUT]
WX	Wind speed in the x direction (m s^{-1})	[OUTPUT]
WY	Wind speed in the y direction (m s^{-1})	[OUTPUT]
DWX	Wind speed gradient in z direction (s^{-1})	
DWY	Wind speed gradient in z direction (s^{-1})	
USTR	Friction velocity, u_* (m s^{-1})	[INPUT]
F	Coriolis parameter (s^{-1})	[INPUT]
ROSTR	Rossby number, Ro	[INPUT]

Listing of Subroutine WINDF

```
      SUBROUTINE WINDF(AMU,Z,WX,WY,DWX,DWY,USTR,F,ROSTR,IZ)
      COMMON/WIND/WDEL(34,11,2),IMU,IMUM,AMUU(34),DW(34,11,2),
     $WXR(34),WYR(34),RAMU,ALFA,UREF,VREF,UDEF
      COMMON/ST/AL
      DMU=AMU-RAMU
      IF(ABS(DMU)-0.01) 3,4,4
    4 IF(AMU.LT.AMUU(1).OR.AMU.GT.AMUU(34)) GO TO 8
      AL=0.4*USTR/(F*AMU)
      RAMU=AMU
      I=1
    9 I=I+1
      IF(AMU.GT.AMUU(I)) GO TO 9
      IMU=I
      IMUM=I-1
      ALFA=AMU*0.06-IMUM+21
      UREF=ALFA*WDEL(IMU,1,1)+(1.-ALFA)*WDEL(IMUM,1,1)
      VREF=ALFA*WDEL(IMU,1,2)+(1-ALFA)*WDEL(IMUM,1,2)
      WRITE(6,16) UREF,VREF
   16 FORMAT(2X,'UREF =',F9.4,3X,'VREF =',F9.4)
      UDEF=(ALOG(ROSTR*0.001+1.0)+0.01125*AMU)/0.4
C**************     COMPUTE ZBAR
    3 Z=Z*F/USTR
      IF (Z.LT.0.001) GO TO 15
      J=1
      ZP=0.001
    5 ZP=ZP+0.01490
      J=J+1
      IF(J.GE.12) GO TO 7
      IF(Z.GT.ZP) GO TO 5
      IZ=J
      IZM=J-1
C**************     COMPUTE WXDEL, WYDEL, WXF, WYF, WX, WY
      DALFA=1.-ALFA
      BETA=(Z-0.001)/0.0149-(IZM-1)
      OBETA=1.-BETA
```

```
      WXDEL=DALFA*DBETA*WDEL(IMUM,IZM,1)+BETA*DALFA*
     $WDEL(IMUM,IZ,1)+ALFA*DBETA*WDEL(IMU,IZM,1)+ALFA*BETA*
     $WDEL(IMU,IZ,1)
      WYDEL=DALFA*DBETA*WDEL(IMUM,IZM,2)+BETA*DALFA*
     $WDEL(IMUM,IZ,2)+ALFA*DBETA*WDEL(IMU,IZM,2)+ALFA*BETA*
     $WDEL(IMU,IZ,2)
      WX=UREF-WXDEL+UDEF
      WY=WYDEL-VREF
      DWX=DALFA*DBETA*DW(IMUM,IZM,1)+BETA*DALFA*DW(IMUM,IZ,1)
     $+ALFA*DBETA*DW(IMU,IZM,1)+ALFA*BETA*DW(IMU,IZ,1)
      DWY=DALFA*DBETA*DW(IMUM,IZM,2)+BETA*DALFA*DW(IMUM,IZ,2)
     $+ALFA*DBETA*DW(IMU,IZM,2)+ALFA*BETA*DW(IMU,IZ,2)
      WX=WX*USTR
      WY=WY*USTR
      DWX=DWX*F
      DWY=DWY*F
      GO TO 1
    7 WRITE(6,700)
      GO TO 1
   15 WY=0.
      WX=USTR*(ALOG(ROSTR*Z+1.)+11.25*AMU*Z)/0.4
      GO TO 1
    8 WRITE(6,710)
  710 FORMAT(5X,'AMU IS OUT OF REGION')
  700 FORMAT(2X,'Z IS LARGER THAN 0.15')
    1 Z=Z*USTR/F
      RETURN
      END
```

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APPENDIX 4A

TABULATED FRONTAL DATA

Tabulated data for two cold air synoptic fronts are given in this appendix. The tables have, due to their length, been split into six parts covering columns 1 through 20, 21 through 40, etc. The tabulated values of W_x are values relative to the storm motion. The frontal speed $\overline{W}_x$ is given at the top of the table for converting W_x to its value relative to the ground.

The case numbers for the two storm fronts studied are listed at the top of the table. Also listed at the top of the table are the horizontal length scales for the given wind record. The horizontal extent of each data set varies because of the data reduction procedure. Hence, the length of field, L, in kilometers and the horizontal grid spacing, Δx, are specified on each table. The vertical extent of each field is taken as 500 m with 50 m vertical grid spacing.

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Table 4A-1(a) Longitudinal Wind Speed, W_x, for Cold Front; Case 1, 0307, $\bar{W}_x$=9.3 m s^{-1}
L=17.4km, ΔX=153.7m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.4	6.4	6.4	6.4	6.3	6.3	6.2	6.2	6.2	6.1
10	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.2	6.3	6.3	6.3	6.3	6.2	6.2	6.2	6.1	6.1	6.1
9	6.0	6.0	6.1	6.1	6.1	6.1	6.0	6.0	6.0	6.0	6.1	6.1	6.2	6.2	6.2	6.1	6.1	6.0	6.0	6.0
8	5.0	5.3	5.6	5.9	5.7	5.5	5.3	5.1	5.3	5.5	5.8	6.0	6.1	6.0	5.8	5.7	5.5	5.4	5.6	5.8
7	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.5	4.4	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.2	4.0	4.8
6	3.0	3.2	3.3	3.5	3.7	3.8	4.0	3.8	3.6	3.5	3.3	3.4	3.5	3.6	3.8	3.9	4.0	2.0	3.0	4.0
5	2.0	2.0	2.0	2.0	2.0	2.3	2.7	3.0	2.7	2.3	2.0	2.0	2.0	2.0	2.0	2.5	3.0	2.4	1.9	2.9
4	1.0	0.7	0.3	0.0	0.5	1.0	1.5	2.0	1.7	1.3	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.3	2.5	2.8
3	0.0	-0.9	-1.9	-2.8	-3.8	0.0	0.3	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.8	1.5	1.1	0.8	1.4
2	-0.5	-1.4	-2.3	-3.1	-4.0	-2.8	-1.7	-0.5	-1.0	-1.5	-2.0	-1.7	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	-0.1	-0.3
1	-1.0	-1.8	-2.5	-3.3	-4.0	-3.2	-2.3	-1.5	-2.3	-3.2	-4.0	-3.4	-2.8	-2.3	-1.7	-1.1	-0.5	-0.9	-1.3	-1.7

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	6.1	6.0	6.0	6.7	7.3	8.0	8.0	8.0	8.0	7.0	6.0	5.7	5.4	5.1	4.8	4.5	4.2	5.1	6.0	6.4
10	6.1	6.0	6.0	6.5	7.0	7.5	8.0	7.5	7.0	6.5	6.0	5.6	5.3	5.0	4.6	4.3	3.9	4.9	6.0	6.3
9	5.9	5.9	5.9	6.2	6.5	6.8	7.1	6.9	6.7	6.4	6.2	6.0	5.5	5.0	4.5	4.0	2.0	4.0	6.0	6.3
8	6.0	5.9	5.8	6.0	6.1	6.3	6.5	6.4	6.3	6.2	6.1	6.0	5.4	4.8	4.2	2.9	1.7	3.8	6.0	6.0
7	5.5	5.6	5.7	5.8	5.9	6.0	6.0	6.0	6.0	6.0	5.0	4.1	4.1	4.0	4.0	2.6	1.5	4.0	6.0	6.0
6	4.1	4.3	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.0	3.5	4.1	2.6	1.1	2.5	4.0	5.5	5.6
5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.0	2.5	2.0	0.2	0.8	1.4	2.0	2.5	3.1	3.6	4.1	4.0
4	3.1	3.1	3.0	3.0	3.0	2.9	2.9	2.3	1.7	1.1	0.4	-0.3	-1.0	1.0	1.3	1.6	1.9	2.2	2.2	2.1
3	2.0	2.0	2.0	2.0	2.1	2.1	2.1	0.0	0.0	0.0	-0.7	-1.3	-2.0	-1.0	0.0	0.6	1.1	1.7	1.4	1.0
2	-0.4	-0.5	-0.7	-0.8	-0.9	-1.1	-1.2	-1.3	-1.5	-1.6	-1.7	-1.9	-2.0	-1.9	-1.8	-1.6	-1.5	-1.4	-1.3	-1.5
1	-2.1	-2.1	-2.1	-2.1	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.3	-2.3	-2.3	-2.2	-2.2	-2.1	-2.1	-2.0	-2.0	-2.0

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	6.8	7.2	7.6	8.0	8.0	8.1	8.1	8.1	8.1	8.2	8.2	8.1	8.1	8.0	8.0	7.9	7.8	7.8	7.7	7.8
10	6.5	6.8	7.0	7.3	7.5	7.7	7.8	8.0	8.1	8.2	8.3	8.4	8.5	8.3	8.2	8.0	7.9	7.8	7.6	7.5
9	6.5	6.6	7.0	7.3	7.5	7.8	8.0	8.1	8.3	8.4	8.5	8.6	8.8	8.9	9.0	8.5	8.0	7.7	7.3	7.0
8	6.0	6.0	6.4	6.8	7.2	7.6	8.0	8.3	8.5	8.8	9.0	9.3	9.5	9.8	10.0	9.3	8.7	8.0	7.8	7.5
7	5.9	5.9	5.9	6.0	6.6	7.3	7.9	8.2	8.5	8.8	9.1	9.4	9.7	10.0	10.0	10.0	10.0	9.0	8.0	7.7
6	5.7	5.7	5.8	5.9	6.0	6.7	7.3	8.0	8.3	8.7	9.0	9.3	9.7	10.0	10.0	10.0	10.0	9.3	8.7	8.0
5	4.0	4.0	4.0	4.0	4.7	5.4	6.1	6.7	7.4	8.0	8.0	8.1	8.1	8.7	9.3	9.9	9.4	8.9	8.5	8.0
4	2.1	2.0	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.4	6.8	7.2	7.6	8.0	7.7	7.4	7.0	6.7
3	0.7	0.3	0.0	0.6	1.1	1.7	2.3	2.9	3.4	4.0	4.3	4.6	4.9	5.1	5.4	5.7	6.0	6.0	6.0	6.0
2	-1.7	-1.9	-2.1	-1.8	-1.5	-1.2	-0.9	-0.6	-0.3	0.0	0.2	0.4	0.7	0.9	1.1	1.3	1.6	1.8	1.8	1.9
1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0	-1.8	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.3

Table 4A-1(a) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	7.9	8.0	8.1	8.2	8.3	8.1	8.0	7.7	7.3	7.0	6.7	6.3	6.0	4.0	3.0	2.0	1.7	1.4	1.1	0.9
10	7.8	8.0	8.1	8.1	8.2	8.1	8.1	8.0	8.0	7.9	7.9	7.8	5.9	4.0	3.4	2.7	2.1	1.4	0.8	0.6
9	7.5	8.0	8.0	8.1	8.1	8.2	8.2	8.2	8.1	8.1	8.0	8.0	6.6	5.3	3.9	3.2	2.4	1.7	1.0	1.3
8	7.7	7.9	8.1	8.1	8.2	8.2	8.3	8.3	8.2	8.2	8.1	8.1	6.0	6.0	4.0	3.3	2.6	1.9	1.2	1.6
7	7.4	7.7	8.0	8.0	8.1	8.1	8.2	8.2	8.3	8.2	8.1	8.1	8.0	6.0	4.0	3.3	2.7	2.0	2.0	2.0
6	7.4	7.6	7.8	8.0	8.1	8.1	8.2	8.2	8.3	8.2	8.1	8.1	8.0	6.8	5.6	4.4	3.2	2.0	2.0	2.0
5	7.0	7.3	7.5	7.8	8.0	8.0	8.1	8.1	8.2	8.1	8.1	8.0	8.0	6.7	5.3	4.0	3.3	2.7	2.0	2.7
4	6.4	6.6	6.8	6.9	7.1	7.3	7.5	7.6	7.8	8.0	7.3	6.7	6.0	5.3	4.7	4.0	3.3	2.7	2.0	2.6
3	6.0	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.1	6.1	6.1	5.6	5.1	4.5	4.0	3.4	2.8	2.2	1.6	2.1
2	1.9	2.0	2.0	1.7	1.5	1.2	1.0	0.7	0.5	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.3
1	0.5	0.8	1.0	0.5	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.4	-0.5	-0.5	-0.6	-0.6	-0.7	-0.7	-0.8	-0.6

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	0.6	0.3	0.0	-2.1	1.9	6.0	7.5	9.0	10.5	12.0	12.0	8.0	0.5	0.0	-0.5	-1.0	-1.5	-2.0	-2.5	-3.0
10	0.5	0.3	0.1	-2.0	1.3	4.7	8.0	9.3	10.7	12.0	12.0	8.0	4.0	0.0	-0.5	-1.0	-1.5	-2.0	-2.4	-2.9
9	1.5	1.8	2.0	0.8	3.2	5.6	8.0	10.0	12.0	10.7	9.3	8.0	5.2	2.4	-0.4	-0.9	-1.3	-1.8	-2.3	-2.7
8	2.0	3.3	4.5	5.8	7.0	8.3	9.6	10.8	12.1	11.1	10.1	9.0	8.0	3.9	-0.2	-0.9	-1.6	-2.3	-3.0	-3.4
7	2.0	3.0	4.0	5.0	6.0	8.9	11.8	12.0	11.5	11.0	10.5	10.0	6.7	3.3	0.0	-2.0	-2.4	-2.6	-3.2	-3.6
6	3.0	4.0	5.0	6.0	7.3	8.7	10.0	11.1	10.8	10.5	10.3	10.0	6.7	3.4	0.1	-2.0	-2.5	-3.0	-3.5	-4.0
5	3.3	4.0	5.0	6.0	7.0	8.0	10.0	10.0	10.0	9.5	9.1	8.7	8.2	4.9	1.5	-1.8	-2.4	-3.0	-3.6	-4.2
4	3.3	3.9	4.7	5.6	6.4	7.2	8.1	8.9	8.7	8.5	8.4	8.2	6.0	5.0	2.0	-1.0	-2.1	-3.2	-3.6	-4.1
3	2.6	3.0	3.5	4.0	4.7	5.5	6.2	6.2	6.2	6.2	6.1	6.1	6.1	6.1	3.1	0.0	-1.0	-2.0	-3.0	-4.0
2	0.6	0.9	1.1	1.4	1.7	2.0	1.7	1.4	1.1	0.7	0.4	0.1	2.0	4.0	3.0	2.0	1.0	0.0	-1.2	-2.4
1	-0.5	-0.3	-0.2	0.0	0.1	0.3	0.2	0.1	0.0	0.4	0.8	1.2	1.6	2.0	1.6	1.2	0.8	0.4	0.0	-1.2

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	-3.5	-4.0	-4.4	-4.8	-5.2	-5.6	-6.0	-6.1	-6.2	-6.3	-6.4	-6.5	-6.6
10	-3.3	-3.8	-4.2	-4.7	-5.1	-5.6	-6.0	-6.1	-6.2	-6.3	-6.4	-6.5	-6.6
9	-3.2	-3.7	-4.1	-4.6	-5.1	-5.5	-6.0	-6.1	-6.3	-6.4	-6.5	-6.7	-6.8
8	-3.9	-4.3	-4.7	-5.1	-5.6	-6.0	-6.1	-6.3	-6.4	-6.6	-6.7	-6.9	-7.0
7	-4.0	-4.5	-5.0	-5.5	-6.0	-6.2	-6.4	-6.6	-6.8	-7.0	-7.2	-7.4	-7.6
6	-4.5	-5.0	-5.5	-6.0	-6.2	-6.4	-6.7	-6.9	-7.1	-7.3	-7.6	-7.8	-8.0
5	-4.8	-5.4	-6.0	-6.3	-6.5	-6.8	-7.0	-7.3	-7.5	-7.8	-8.0	-8.0	-8.1
4	-4.5	-5.0	-5.4	-5.9	-6.4	-6.9	-7.5	-8.0	-8.0	-8.1	-8.1	-8.2	-8.2
3	-5.0	-6.0	-6.4	-6.6	-7.2	-7.6	-8.0	-8.0	-8.1	-8.1	-8.2	-8.2	-8.3
2	-3.6	-4.8	-6.0	-6.4	-6.8	-7.2	-7.6	-8.0	-8.0	-8.1	-8.1	-8.2	-8.2
1	-2.4	-3.6	-4.8	-6.0	-6.4	-6.6	-7.2	-7.6	-8.0	-8.0	-8.1	-8.1	-8.2

Table 4A-1(b) Lateral Wind Speed, W_y, for Cold Front; Case 1, 0307, $\overline{W}_x$=9.3 m s^{-1}

L=17.4 km, ΔX=153.7 m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	-3.8	-3.8	-3.9	-3.9	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
10	-3.9	-3.9	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-3.8	-3.6	-3.3	-3.1	-2.9	-3.1	-3.3	-3.6
9	-4.0	-4.0	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-3.7	-3.4	-3.1	-2.8	-3.0	-3.3	-3.5
8	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0	-3.5	-3.0	-3.1	-3.3	-3.4	-3.5	-3.6	-3.8
7	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-3.0	-2.0	-2.1	-2.3	-2.4	-2.5	-2.6	-2.8
6	-3.8	-3.9	-3.9	-4.0	-3.8	-3.5	-3.3	-3.0	-0.6	1.8	4.2	2.8	1.3	-0.1	-1.0	-2.0	-2.0	-2.1	-2.1	-2.1
5	-3.0	-3.5	-4.0	-3.6	-3.2	-2.8	-2.4	-2.0	-2.7	-3.4	-4.1	-2.7	-1.4	0.0	-0.7	-1.3	-2.0	-2.0	-2.0	-2.0
4	-2.2	-2.6	-3.0	-2.7	-2.3	-2.0	-2.0	-2.0	-2.0	-3.0	-4.0	-2.7	-1.3	0.0	-0.5	-1.0	-1.5	-2.0	-1.8	-1.5
3	-2.0	-1.9	-1.8	-1.8	-1.7	-1.4	-1.2	-0.9	-1.6	-2.4	-3.1	-2.2	-1.2	-0.3	-0.6	-1.0	-1.3	-1.7	-1.5	-1.3
2	-0.9	-0.7	-0.5	-0.4	-0.2	0.0	-0.4	-0.8	-1.2	-1.6	-2.0	-1.6	-1.2	-0.8	-0.7	-0.7	-0.6	-0.5	-0.5	-0.4
1	0.0	-0.2	-0.4	-0.5	-0.7	-0.9	-1.1	-1.3	-1.4	-1.6	-1.8	-1.5	-1.3	-1.0	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	-4.0	-4.0	-4.0	-3.0	-3.5	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	0.0	-0.1	-0.3
10	-3.8	-4.0	-3.0	-2.0	-2.7	-3.3	-4.0	-4.0	-4.0	-4.0	-4.0	-3.6	-3.2	-3.6	-4.0	-4.0	-2.0	0.0	-0.1	-0.3
9	-3.8	-4.0	-3.0	-2.0	-1.0	-2.5	-4.0	-4.0	-4.0	-4.0	-3.7	-3.3	-3.0	-3.5	-4.0	-4.0	-2.7	-1.3	0.0	0.0
8	-3.9	-4.0	-2.0	0.0	-1.0	-2.0	-3.1	-4.1	-3.9	-3.8	-3.6	-3.5	-3.6	-3.8	-3.9	-4.0	-2.0	0.0	0.0	0.0
7	-2.9	-3.0	-2.0	0.0	0.0	-2.0	-2.7	-3.3	-4.0	-3.3	-2.7	-2.0	-2.2	-2.5	-2.7	-1.4	-0.1	0.0	0.0	0.0
6	-2.0	-2.0	-2.0	0.0	0.0	-2.0	-2.5	-3.0	-2.5	-2.0	-1.1	-0.3	-1.2	-2.1	-1.4	-0.7	0.0	0.0	0.0	0.0
5	-2.0	-2.0	-2.0	-1.1	-0.1	-1.0	-2.0	-2.0	-2.0	-1.0	0.0	-1.0	-2.0	-1.3	-0.7	0.0	0.0	0.0	0.0	0.0
4	-1.3	-1.1	-0.9	-0.6	-0.4	-0.8	-1.1	-1.5	-0.8	0.0	-0.3	-0.6	-1.0	-1.3	-0.6	0.1	0.1	0.0	0.0	0.0
3	-1.1	-1.0	-0.8	-0.6	-0.4	-0.6	-0.8	-1.0	-0.7	-0.3	0.0	-0.3	-0.6	-0.3	0.0	0.0	0.1	0.0	0.0	0.0
2	-0.4	-0.3	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.0
1	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.1

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	-0.4	-0.6	-0.7	-0.9	-1.0	-1.1	-1.3	-1.4	-1.6	-1.7	-1.9	-2.0	-2.0	-2.0	-2.0	-1.0	0.0	0.0	0.0	0.0
10	-0.4	-0.6	-0.7	-0.9	-1.0	-1.1	-1.3	-1.4	-1.6	-1.7	-1.9	-2.0	-2.0	-2.0	-1.5	-1.0	-0.5	0.0	0.0	0.0
9	0.0	-0.2	-0.4	-0.5	-0.7	-0.9	-1.1	-1.3	-1.5	-1.6	-1.8	-2.0	-1.7	-1.3	-1.0	-0.7	-0.3	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	-0.3	-0.5	-0.8	-1.0	-1.3	-1.5	-1.8	-2.0	-1.6	-1.2	-0.8	-0.4	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-0.6	-0.9	-1.3	-1.6	-1.9	-1.6	-1.3	-0.9	-0.6	-0.3	0.0	0.2	0.3
6	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4	-0.6	-0.8	-1.0	-1.2	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	0.2	0.4
5	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.4	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4A-1(b) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.1	2.4	2.8	3.1	3.5	3.8
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.4	2.8	3.2	3.6	4.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.2	0.0	0.0	0.0	1.0	2.0	2.5	3.0	3.5	4.0	4.0
8	0.0	0.0	0.0	0.0	0.0	0.3	0.7	1.0	0.8	0.6	0.4	0.2	0.6	1.4	2.0	2.7	3.3	4.0	4.0	4.0
7	0.5	0.4	0.4	0.3	0.3	0.9	1.4	2.0	1.6	1.3	0.9	0.5	1.0	1.5	2.0	3.0	4.0	4.0	4.0	4.0
6	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.0	2.0	1.4	0.8	1.2	1.6	2.0	3.0	4.0	4.0	4.0	4.0
5	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	1.7	1.4	1.2	0.9	1.4	2.0	3.0	4.0	4.0	4.0	4.0
4	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	1.6	1.5	1.3	1.0	1.4	1.9	2.3	2.7	3.1	3.6	4.0
3	0.2	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.0	2.0	2.0
2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.3	0.4
1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	2.3	0.9	-0.6	-2.0	-1.8	-1.6	-1.3	-1.1	-0.9	-0.7	-0.4	-0.2	0.0	2.0	4.0	4.3	4.6	4.9	5.1	5.4
10	2.5	1.0	-0.5	-2.0	-1.5	-1.0	-0.5	0.0	0.0	0.0	0.0	0.0	1.3	2.7	4.0	4.3	4.5	4.8	5.0	5.3
9	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	2.7	4.0	4.2	4.4	4.7	4.9	5.1
8	4.0	4.0	2.7	1.5	0.2	0.2	0.1	0.1	0.1	0.0	0.0	1.0	2.0	3.0	4.1	4.3	4.4	4.6	4.8	5.0
7	4.0	4.0	4.0	3.0	2.0	1.6	1.1	0.7	0.3	0.7	1.1	1.6	2.0	3.0	4.1	4.3	4.4	4.6	4.8	4.9
6	4.0	4.0	4.0	3.0	2.0	1.6	1.1	0.7	0.3	0.7	1.1	1.6	2.0	3.0	4.0	4.2	4.4	4.6	4.8	5.0
5	4.0	4.0	4.0	3.0	2.0	1.6	1.2	0.8	0.4	0.8	1.2	1.6	2.0	3.0	4.0	4.3	4.5	4.5	4.5	4.5
4	3.6	3.2	2.8	2.4	2.0	1.5	0.9	0.4	0.7	0.9	1.2	1.5	1.7	2.0	2.7	3.5	4.2	4.2	4.2	4.2
3	2.0	2.0	2.0	1.7	1.3	1.0	0.6	0.3	0.3	0.2	0.2	0.1	0.1	1.0	1.9	2.9	3.8	3.8	3.8	3.8
2	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.5	0.5	0.5

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	5.7	6.0	6.0	6.1	6.1	6.1	6.2	6.2	6.3	6.3	6.3	6.4	6.4
10	5.5	5.8	6.0	6.0	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.3	6.3
9	5.3	5.6	5.8	6.0	6.0	6.0	6.1	6.1	6.1	6.1	6.2	6.2	6.2
8	5.1	5.3	5.5	5.7	5.8	6.0	6.0	6.0	6.0	6.1	6.1	6.1	6.1
7	5.0	5.1	5.3	5.4	5.5	5.5	5.5	5.5	5.5	5.6	5.6	5.6	5.6
6	5.0	5.0	5.1	5.1	5.1	5.1	5.2	5.2	5.2	5.2	5.3	5.3	5.3
5	4.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7
4	4.2	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
3	3.8	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	4.0	4.0	4.0	4.0
2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Table 4A-1(c) Vertical Wind Speed, W_z, for Cold Front; Case 1, 0307, $\bar{W}_x$=9.3 m s^{-1}

L=17.4 km, ΔX=153.7 m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0
6	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
5	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3
4	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.4	-0.3	-0.2	0.0	0.1	0.2	0.1	-0.1	-0.2	-0.3	-0.5	-0.6	-0.5
3	0.0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.3	-0.2	-0.1	0.1	0.2	0.3	0.2	0.0	-0.1	-0.2	-0.4	-0.5	-0.4
2	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	-0.1	0.0	0.3	0.7	1.0	1.2	1.0	0.6
10	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.4	0.7	1.1	0.7	0.4
9	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.5	1.0	0.7	0.3
8	0.0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.8	0.5	0.3
7	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.3	0.6	0.3
6	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.5	0.0
5	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	-0.4	-0.3	-0.2	-0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.2	-0.2	-0.1	0.0	0.0	0.0	0.0	0.1	0.0
3	-0.3	-0.3	-0.2	-0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.2	-0.1	-0.1	0.0	0.1	0.2	0.3	0.1	0.0
2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	0.1	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.3	0.7	1.0	1.0	1.0	0.9
10	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.3	0.5	0.8	1.0	0.9	0.8
9	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.3	0.7	1.0	0.9	0.8
8	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.3	0.6	0.5	0.4
7	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.2	0.4	0.3
6	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2	0.3
5	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.2	0.1
4	0.0	-0.1	-0.2	-0.3	-0.4	-0.3	-0.2	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
3	-0.1	-0.2	-0.3	-0.4	-0.5	-0.4	-0.3	-0.1	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0
2	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4A-1(c) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	0.8	0.6	0.5	0.4	0.3	0.1	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.0	2.0	2.0	1.3	0.7	0.0
10	0.7	0.6	0.4	0.3	0.2	0.1	0.0	0.3	0.6	0.9	1.1	1.4	1.7	2.0	2.0	2.0	2.0	1.3	0.7	0.0
9	0.6	0.5	0.4	0.3	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	0.0	0.7	1.3	2.0	2.0	1.5	1.0	0.3	-0.3
8	0.4	0.3	0.2	0.2	0.1	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.4	0.8	1.1	1.5	1.0	0.6	0.1	-0.2
7	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.7	1.0	1.0	1.0	0.6	0.1	-0.2
6	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.8	0.6	0.5	0.3	0.2	0.0
5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.6	0.5	0.4	0.2	0.1	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.4	0.2	0.1	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	-1.1	-1.6	-2.0	-2.5	-3.0	-4.2	-4.2	-2.1	0.0	1.1	2.1	3.0	4.0	4.1	4.2	3.8	3.4	3.0	2.6	2.2
10	-0.5	-1.1	-1.4	-1.8	-2.9	-4.1	-4.1	-2.1	0.0	1.1	1.0	1.0	2.0	3.1	4.2	3.8	3.3	2.9	2.4	2.0
9	-1.0	-1.0	-1.0	-1.5	-2.1	-4.0	-4.0	-1.8	0.5	1.0	0.6	0.5	1.6	2.8	3.9	3.5	3.1	2.7	2.2	1.8
8	-0.4	-0.7	-0.8	-1.0	-2.2	-3.4	-2.1	-0.8	0.5	1.0	0.5	0.0	1.1	2.3	3.4	3.0	2.7	2.3	2.0	1.6
7	-0.4	-0.7	-1.0	-1.2	-1.5	-3.0	-1.9	-0.8	0.3	0.2	0.1	0.0	0.8	1.7	2.5	2.2	1.9	1.6	1.3	1.0
6	-0.2	-0.4	-0.6	-0.8	-1.0	-2.0	-1.0	0.0	0.3	0.5	0.3	0.0	0.6	1.2	1.8	1.7	1.6	1.5	1.4	1.3
5	-0.2	-0.3	-0.5	-0.7	-0.6	-1.0	-0.5	0.0	0.1	0.3	0.0	0.0	0.0	0.5	1.0	0.9	0.9	0.8	0.8	0.7
4	-0.1	-0.3	-0.4	-0.3	-0.2	-0.2	-0.1	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3
3	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	1.8	1.4	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
10	1.5	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
9	1.4	1.0	0.9	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.2	0.1	0.0
8	1.3	0.9	0.8	0.7	0.7	0.6	0.5	0.4	0.3	0.2	0.2	0.1	0.0
7	0.9	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.3	0.2	0.2	0.1	0.0
6	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
5	0.7	0.6	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0
4	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0
3	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A4-2(a) Longitudinal Wind Speed, W_x, for Cold Front; Case 2, 1050, $\bar{W}_x$=7.1 m s^{-1}

L=13.2 km, ΔX=117.7m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	-0.2	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0
10	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0
9	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.6
8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0
7	2.3	2.4	2.5	2.6	2.6	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2
6	2.6	2.8	3.0	3.2	3.1	3.1	3.0	2.9	2.9	2.8	2.7	2.7	2.6	2.6	2.5	2.4	2.4	2.3	2.3	2.3
5	3.1	3.4	3.7	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.1	3.0	2.9	2.8	2.7	2.6	2.5	2.5	2.5
4	3.3	4.0	4.0	4.0	4.0	3.9	3.7	3.6	3.4	3.3	3.2	3.0	2.9	2.8	2.6	2.5	2.3	2.2	2.2	2.3
3	2.9	3.3	3.6	4.0	3.8	3.7	3.5	3.3	3.2	3.0	2.8	2.7	2.5	2.3	2.2	2.0	1.9	1.9	2.0	2.0
2	2.3	2.3	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.0	2.0	1.9	1.8	1.7	1.6	1.5	1.4	1.4	1.4
1	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.8	1.7	1.6	1.5	1.4	1.3	1.2	1.1	0.9	0.8	0.7	0.6	0.5

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	0.0	0.0	-0.3	-0.5	-0.8	-1.0	-1.3	-1.5	-1.8	-2.0	-2.0	-2.0	-1.6	-1.1	-0.7	-0.3	-1.1	-2.0	-2.0	-2.0
10	1.0	1.0	0.7	0.3	0.0	-0.3	-0.5	-0.8	-1.0	-1.3	-1.5	-1.0	-0.5	0.0	0.0	0.0	0.0	-0.5	-1.1	-1.1
9	1.5	1.5	1.5	1.3	1.1	0.9	0.8	0.6	0.4	0.2	0.0	0.2	0.5	0.7	1.0	1.2	0.8	0.4	0.0	0.0
8	2.0	2.0	2.0	2.0	2.0	1.9	1.9	1.9	1.9	1.4	1.0	1.2	1.4	1.6	1.8	2.0	1.6	1.3	1.0	0.6
7	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.1	2.1	2.0	2.0	1.4	0.8
6	2.3	2.3	2.3	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.0	2.0	1.8
5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	2.0
4	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.2	2.1	2.1	2.0	2.0	2.2
3	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.1	2.1	2.2	2.1	2.1	2.0	2.0	1.9	1.9	1.9
2	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.5	1.3	1.2	1.0	0.8	1.1	1.4
1	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.8	1.0	0.8	0.5	0.3	0.0	0.0	0.0	0.0

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	-2.1	-2.1	-2.1	-2.1	-2.2	-2.2	-2.2	-2.6	-3.1	-3.5	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0	-4.0
10	-1.1	-1.1	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.5	-1.8	-2.1	-2.5	-3.0	-2.9	-2.8	-2.6	-2.5	-2.4	-2.3	-2.1
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-0.9	-1.4	-1.5	-1.5	-1.6	-1.7	-1.7	-1.8
8	0.7	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	0.9	0.7	0.5	0.4	0.2	0.0	0.1	0.2
7	1.2	1.6	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.6	1.3	1.0	0.6	0.9	1.3	1.6
6	1.9	2.0	2.1	2.2	2.3	2.5	2.6	2.7	2.8	3.0	3.1	3.2	2.8	2.5	2.1	1.8	1.9	2.0	2.1	1.9
5	2.0	2.2	2.4	2.5	2.7	2.9	3.1	3.3	3.5	3.6	3.8	4.0	3.6	3.2	2.8	2.4	2.0	2.0	2.1	2.1
4	2.3	2.5	2.7	2.8	3.0	3.2	3.3	3.5	3.7	3.8	4.0	4.0	4.0	3.5	3.0	2.5	2.0	2.2	2.3	2.5
3	2.0	2.1	2.2	2.3	2.5	2.6	2.7	2.8	3.2	3.6	4.0	4.0	4.0	3.6	3.2	2.7	2.3	1.9	2.0	2.0
2	1.7	2.0	2.1	2.2	2.3	2.5	2.6	2.7	3.1	3.6	4.0	3.6	3.2	2.8	2.4	2.0	1.7	1.4	1.7	2.0
1	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.6	3.2	3.0	2.7	2.5	2.2	2.0	1.6	1.2	1.4	1.6

Table 4A-2(a) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	-3.5	-3.1	-3.3	-3.5	-3.6	-4.0	-4.0	-4.0	-4.0	-4.0	0.0	0.3	0.7	1.0	0.0	0.0	0.0	0.0	2.0	2.0
10	-2.0	-2.3	-2.7	-3.0	-3.3	-3.7	-4.0	-4.0	-4.0	-2.9	-1.9	-0.8	0.6	2.0	1.0	0.0	0.6	1.3	1.9	2.6
9	-1.9	-1.9	-2.0	-2.3	-2.7	-3.0	-3.3	-3.7	-4.0	-3.0	-2.0	0.0	1.0	2.0	1.4	0.8	0.2	1.2	2.3	3.3
8	0.3	0.1	-0.2	-0.4	-0.7	-1.3	-2.0	-2.5	-3.0	-2.0	-1.0	0.0	1.0	2.1	2.0	1.8	1.7	2.5	3.2	4.0
7	2.0	1.5	1.0	0.5	0.0	-0.5	-1.0	-1.5	-2.0	-1.0	0.0	1.0	2.0	2.4	2.9	2.5	2.1	3.0	4.0	4.0
6	1.7	1.5	1.3	1.1	0.8	0.6	0.4	0.2	0.0	0.4	0.9	1.3	1.8	2.2	2.7	3.1	3.6	4.0	4.0	4.0
5	2.2	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.1
4	2.7	2.8	3.0	3.2	3.3	3.5	3.7	3.8	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.0
3	2.1	2.4	2.7	3.0	3.4	3.7	4.0	4.0	4.1	4.1	4.2	4.2	4.1	4.1	4.1	4.0	4.0	3.7	3.4	3.1
2	2.3	2.5	2.8	3.0	3.3	3.5	3.8	4.0	4.0	4.1	4.1	4.0	4.0	4.0	3.7	3.3	3.0	2.7	2.3	2.0
1	1.8	2.0	2.3	2.6	2.9	3.1	3.4	3.7	4.0	4.0	4.0	3.5	3.0	2.6	2.1	1.7	1.4	1.1	0.7	0.4

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	0.0	-2.0	-4.0	-4.0	-3.1	-2.2	-3.1	-4.0	-5.0	-6.0	-6.0	-6.0	-5.9	-5.8	-5.6	-5.5	-5.4	-5.3	-5.3	-5.3
10	0.3	-2.0	-2.6	-3.2	-2.1	-1.0	-2.0	-3.0	-4.0	-4.5	-5.0	-5.5	-5.4	-5.3	-5.3	-5.2	-5.1	-5.0	-5.0	-5.0
9	3.3	1.6	0.0	-1.7	0.0	0.0	0.0	-0.7	-1.3	-2.0	-3.9	-4.0	-4.2	-4.3	-4.4	-4.5	-4.7	-4.8	-4.8	-4.8
8	2.7	1.3	0.0	0.7	1.3	2.0	1.3	0.7	0.0	-1.0	-2.0	-3.9	-4.1	-4.3	-4.4	-4.6	-4.8	-5.0	-5.0	-5.0
7	4.0	3.0	2.0	2.2	2.4	2.6	2.8	2.4	2.0	0.5	-1.0	-2.5	-4.0	-4.3	-4.5	-4.8	-5.0	-5.0	-5.0	-5.0
6	4.0	4.0	3.1	2.2	2.8	3.3	3.9	3.3	2.6	2.0	0.5	-1.0	-2.5	-4.0	-4.4	-4.7	-5.1	-5.1	-5.1	-5.1
5	4.0	4.0	3.3	2.7	3.3	4.0	4.0	4.0	2.7	1.3	0.0	-1.3	-2.7	-4.0	-4.3	-4.7	-5.0	-5.4	-5.4	-5.4
4	4.0	3.6	3.2	2.8	3.1	3.4	3.7	4.0	3.0	2.0	1.0	-0.7	-2.3	-4.0	-4.4	-4.8	-5.3	-5.7	-5.7	-5.7
3	2.9	2.6	2.3	2.0	2.3	2.6	2.9	3.2	3.5	2.3	1.2	0.0	-2.0	-4.0	-4.7	-5.3	-6.0	-6.0	-6.0	-6.0
2	1.8	1.5	1.3	1.1	1.4	1.7	2.0	2.3	1.7	1.1	0.6	0.0	-2.0	-4.0	-5.0	-6.0	-6.0	-6.0	-6.1	-6.1
1	0.0	0.0	0.0	0.5	0.9	1.4	1.9	1.5	1.1	0.8	0.4	0.0	-2.0	-4.0	-6.0	-6.0	-6.0	-6.1	-6.1	-6.1

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	-5.3	-5.3	-5.3	-5.3	-5.3	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2
10	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0	-5.0
9	-4.8	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-4.9	-5.0	-5.0	-5.0	-5.0
8	-5.0	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.2	-5.2	-5.2	-5.2
7	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.1	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2
6	-5.1	-5.1	-5.1	-5.1	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2	-5.3	-5.5
5	-5.4	-5.4	-5.4	-5.4	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5	-5.6	-6.0
4	-5.7	-5.7	-5.7	-5.8	-5.8	-5.8	-5.8	-5.8	-5.8	-5.9	-5.9	-6.0	-6.2
3	-6.0	-6.0	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	-6.1	-6.2	-6.2	-6.2
2	-6.1	-6.1	-6.1	-6.1	-6.2	-6.2	-6.2	-6.2	-6.2	-6.2	-6.3	-6.3	-6.3
1	-6.1	-6.2	-6.2	-6.2	-6.2	-6.3	-6.3	-6.3	-6.3	-6.3	-6.4	-6.4	-6.4

Table 4A-2(b) Lateral Wind Speed, W_y for Cold Front; Case 2, 1050, $\bar{W}_x$=7.1 m s^{-1}

L=13.2 km, ΔX=117.7m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	1.6
10	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.0
9	-2.0	-1.9	-1.8	-1.7	-1.6	-1.5	-1.4	-1.3	-1.2	-1.1	-1.0	-1.1	-1.3	-1.4	-1.5	-1.6	-1.8	-1.9	-2.0	-1.8
8	-2.1	-2.2	-2.2	-2.3	-2.3	-2.4	-2.4	-2.5	-2.5	-2.6	-2.6	-2.7	-2.7	-2.8	-2.7	-2.7	-2.6	-2.6	-2.5	-2.5
7	-2.2	-2.3	-2.5	-2.6	-2.8	-2.9	-3.0	-3.2	-3.3	-3.4	-3.6	-3.7	-3.9	-4.0	-3.9	-3.7	-3.6	-3.4	-3.3	-3.1
6	-2.3	-2.5	-2.6	-2.8	-2.9	-3.1	-3.2	-3.4	-3.5	-3.7	-3.8	-4.0	-4.0	-4.0	-4.0	-3.9	-3.8	-3.7	-3.6	-3.5
5	-2.4	-2.5	-2.7	-2.8	-2.9	-3.1	-3.2	-3.3	-3.5	-3.6	-3.7	-3.9	-4.0	-3.9	-3.9	-3.8	-3.7	-3.7	-3.6	-3.5
4	-2.3	-2.4	-2.4	-2.5	-2.5	-2.6	-2.6	-2.7	-2.8	-2.8	-2.9	-2.9	-3.0	-2.8	-2.6	-2.5	-2.3	-2.1	-2.2	-2.3
3	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.9	-1.9	-2.0
2	-0.6	-0.6	-0.7	-0.7	-0.7	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9	-0.8	-0.8	-0.8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	1.3	1.6	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.5	2.9	3.3
10	0.0	0.2	0.4	0.6	0.8	0.9	1.1	1.3	1.5	1.7	1.9	1.9	1.8	1.8	1.6	1.7	1.7	1.8	1.9	2.0
9	-1.7	-1.5	-1.3	-1.2	-1.0	-0.8	-0.7	-0.5	-0.3	-0.2	0.0	-0.2	-0.3	-0.5	-0.7	-0.5	-0.4	-0.2	0.0	0.6
8	-2.4	-2.4	-2.3	-2.3	-2.2	-2.2	-2.1	-2.1	-2.0	-2.0	-1.6	-1.2	-1.5	-1.7	-2.0	-2.0	-2.0	-2.0	-1.6	-1.2
7	-3.0	-2.8	-2.7	-2.5	-2.4	-2.4	-2.3	-2.3	-2.3	-2.3	-2.2	-2.2	-2.2	-2.2	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0
6	-3.4	-3.3	-3.2	-3.1	-3.0	-2.9	-2.8	-2.8	-2.7	-2.7	-2.6	-2.6	-2.6	-2.5	-2.5	-2.4	-2.4	-2.4	-2.3	-2.3
5	-3.5	-3.4	-3.4	-3.3	-3.2	-3.2	-3.1	-3.1	-3.0	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.8	-2.6	-2.8	-2.7	-2.7
4	-2.4	-2.5	-2.6	-2.7	-2.8	-2.9	-3.0	-3.0	-3.0	-2.9	-2.9	-2.9	-2.9	-2.8	-2.6	-2.6	-2.8	-2.7	-2.7	-2.7
3	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
2	-0.7	-0.7	-0.7	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.6	-1.0	-1.3
1	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	3.7	4.1	3.9	3.7	3.4	3.2	3.0	2.8	3.0	3.3	3.5	3.8	4.0	4.0	4.0	4.0	3.6	3.2	2.9	2.5
10	2.1	2.3	2.2	7.1	2.1	2.0	2.0	2.0	2.0	2.0	2.0	2.3	2.7	3.0	2.7	2.5	2.2	1.9	1.6	1.4
9	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.6	1.8	1.8	1.9	1.9
8	-0.8	-0.7	-0.5	-0.4	-0.3	-0.1	0.0	-0.1	-0.3	-0.4	-0.6	-0.4	-0.3	-0.2	0.0	0.0	0.1	0.1	0.2	0.2
7	-2.0	-1.8	-1.7	-1.5	-1.3	-1.2	-1.0	-1.3	-1.5	-1.8	-2.0	-1.8	-1.7	-1.5	-1.4	-1.2	-1.1	-0.9	-0.8	-0.6
6	-2.2	-2.2	-2.2	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
5	-2.7	-2.7	-2.6	-2.6	-2.6	-2.5	-2.5	-2.5	-2.4	-2.4	-2.4	-2.4	-2.3	-2.3	-2.3	-2.2	-2.2	-2.2	-2.1	-2.1
4	-2.7	-2.6	-2.6	-2.6	-2.6	-2.5	-2.5	-2.5	-2.5	-2.4	-2.4	-2.4	-2.4	-2.3	-2.3	-2.3	-2.3	-2.2	-2.2	-2.2
3	-2.1	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1
2	-1.7	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.7	-0.7	-0.7	-0.7	-0.7

Table 4A-2(b) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.0	-1.0	-1.1	-1.3	-0.8	-0.3	0.2	0.5	0.7	1.0	1.0	1.0	0.7
10	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-1.2	-1.1	-1.1	0.0	0.2	0.4	0.7	0.9	1.1	0.8	0.5
9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-1.2	-1.1	-1.0	0.0	0.2	0.4	0.6	0.8	1.0	0.7	0.3
8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.0	-1.1	-1.0	-1.0	0.0	0.0	0.0	0.0	0.2	0.4	0.3	0.1
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.5	-1.0	-1.0	-1.0	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.9	-1.0	-1.0	-1.0	-0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
5	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-0.8	-0.9	-1.0	-1.0	-1.0	-0.5	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
4	-0.1	-0.2	-0.3	-0.4	-0.6	-0.7	-0.6	-0.9	-1.0	-1.0	-0.7	-0.3	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
3	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.6	-0.9	-0.7	-0.5	-0.2	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
2	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3	-0.4	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	0.3	0.0	0.0	0.0	0.0	1.0	2.0	3.0	4.0	4.0	4.0	4.0	4.0	3.0	1.9	0.9	0.8	0.7	0.6	0.5
10	0.3	0.0	0.1	0.3	0.4	0.6	0.7	0.9	2.0	3.0	4.1	3.5	2.6	2.2	1.5	0.9	0.8	0.8	0.7	0.6
9	0.0	0.0	0.0	0.1	0.1	0.4	0.6	0.9	1.9	2.9	3.9	3.2	2.4	1.7	1.0	0.9	0.8	0.8	0.7	0.6
8	0.0	0.0	0.0	0.1	0.1	0.4	0.6	0.9	1.7	2.6	3.4	3.0	2.7	1.8	1.0	0.8	0.6	0.4	0.2	0.0
7	0.0	0.0	0.1	0.1	0.2	0.4	0.6	0.8	1.3	1.9	2.4	3.0	2.3	1.7	1.0	0.8	0.5	0.3	0.0	0.0
6	0.3	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	2.4	1.7	1.1	0.9	0.7	0.4	0.2	0.0	0.0
5	0.2	0.3	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	2.0	2.0	1.1	0.9	0.7	0.4	0.2	0.0	0.0
4	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.5	1.2	0.9	0.6	0.3	0.0	0.0	0.0	0.0
3	0.2	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.6	0.8	0.9	1.0	0.8	0.5	0.3	0.0	0.0	0.0	0.0
2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.5	0.3	0.2	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	0.4	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.6	0.5	0.5	0.4	0.3	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0
9	0.5	0.4	0.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 4A-2(c) Vertical Wind Speed, W_z, for Cold Front; Case 2, 1050, $\bar{W}_x$=7.1 m s^{-1}

L=13.2 km, ΔX=117.7m

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	0.0	-0.2	-0.4	-0.2	-0.1	0.1	0.2	0.4	0.2	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	-0.1	-0.1	0.0	0.0
10	0.0	-0.2	-0.4	-0.3	-0.1	0.0	0.3	0.5	0.3	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.2	-0.1	0.0	0.0
9	0.0	-0.1	-0.2	-0.1	0.0	0.1	0.2	0.3	0.1	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.2	-0.1	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.0	-0.1	-0.2	-0.3	-0.4	-0.3	-0.2	-0.1	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.0	-0.1	-0.2	-0.3	0.3	0.8	1.4	2.0	1.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.3	-0.2	-0.1	-0.1	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	-0.1
3	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
2	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
11	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.2	0.0	-0.1	0.0
10	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.1	0.2	0.3	0.4	0.2	-0.1	-0.3	0.0
9	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.6	0.3	-0.1	-0.4	-0.1
8	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.5	0.2	0.0	-0.3	0.0
7	-0.1	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	0.0	0.0	0.1	0.1	0.2	0.0	-0.2	0.0
6	-0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.2	0.1	-0.1	0.1
5	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
11	0.0	0.2	0.1	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.4	-0.3	-0.2	-0.1	0.1	0.2	0.3	0.4	0.5	0.4	0.4
10	0.1	0.3	0.1	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.4	-0.3	-0.2	0.0	0.2	0.3	0.5	0.7	0.6	0.4
9	0.2	0.5	0.3	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-0.5	-0.4	-0.2	-0.1	0.1	0.2	0.4	0.5	0.7	0.5	0.4
8	0.2	0.5	0.3	0.0	-0.1	-0.3	-0.4	-0.6	-0.7	-0.4	-0.2	0.1	0.2	0.3	0.4	0.5	0.6	0.5	0.4	0.2
7	0.2	0.4	0.2	0.0	-0.1	-0.2	-0.4	-0.5	-0.6	-0.4	-0.3	-0.2	0.0	0.1	0.3	0.4	0.5	0.4	0.3	0.1
6	0.2	0.1	0.0	0.1	0.0	-0.1	-0.3	-0.4	-0.5	-0.4	-0.3	-0.1	0.0	0.1	0.2	0.3	0.4	0.3	0.1	0.0
5	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2	-0.3	-0.4	-0.3	-0.1	0.0	0.1	0.1	0.2	0.3	0.2	0.1	0.0
4	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.2	-0.2	-0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	-0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 4A-2(c) Continued

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
11	2.1	2.6	3.0	3.5	4.0	4.5	5.0	5.6	6.1	5.5	4.9	5.2	5.4	5.7	6.0	4.7	3.3	2.0	1.8	1.7
10	1.1	1.7	2.3	2.8	3.4	4.0	4.1	4.2	4.2	4.3	4.4	4.3	4.2	4.2	4.1	4.0	3.0	2.0	1.8	1.7
9	1.9	1.9	2.0	2.0	2.4	2.8	3.2	3.6	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.3	2.7	2.0	1.8	1.7
8	0.3	0.6	1.0	1.3	1.7	2.0	2.0	2.0	2.6	3.7	3.6	3.4	3.3	3.2	2.9	2.6	2.3	2.0	1.8	1.6
7	-0.5	-0.3	-0.2	0.0	0.4	0.8	1.2	1.6	2.0	2.2	2.3	2.5	2.7	2.5	2.3	2.2	2.0	1.6	1.1	0.7
6	-2.0	-2.0	-1.5	-1.0	-0.5	0.0	0.3	0.6	0.9	1.2	1.5	1.8	1.6	1.3	1.1	0.9	0.7	0.4	0.2	0.0
5	-2.1	-2.1	-2.0	-2.0	-1.6	-1.2	-0.8	-0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	-2.2	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-1.6	-1.5	-1.3	-1.0	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-0.9	-0.9
3	-2.1	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
2	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.1	-2.1	-2.2	-2.2	-2.2	-2.1	-2.1	-2.1	-2.1	-2.0	-2.0	-2.0
1	-0.7	-0.7	-0.7	-0.7	-0.7	-1.0	-1.3	-1.7	-2.0	-1.9	-1.9	-1.8	-1.7	-1.7	-1.6	-1.4	-1.2	-1.0	-0.8	-0.6

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
11	1.5	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	6.0	6.0	8.0	8.1	8.1	8.1	8.1	8.2	8.2
10	1.5	1.7	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	6.0	7.0	8.0	8.0	8.1	8.1	8.1	8.2	8.2
9	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	2.0	4.0	6.0	6.7	7.3	8.0	8.0	8.0	8.1	8.1	8.1
8	1.4	1.2	1.0	0.8	0.6	0.4	0.9	1.4	2.0	2.5	3.0	4.6	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6
7	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1.5	3.1	4.6	6.2	6.3	6.5	6.6	6.7	6.8	7.0	7.1
6	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0	1.5	3.0	4.6	6.1	6.2	6.3	6.4	6.4	6.5	6.6	6.7
5	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	-0.1	0.0	1.5	3.0	4.5	6.0	6.0	6.0	6.0	6.0	6.1	6.1	6.1
4	-0.9	-0.8	-0.6	-0.5	-0.4	-0.3	-0.1	0.0	0.7	1.3	2.0	3.8	5.6	5.6	5.6	5.7	5.7	5.7	5.7	5.8
3	-1.7	-1.4	-1.1	-0.9	-0.6	-0.3	0.0	0.5	1.0	1.5	2.0	4.0	4.4	4.3	4.3	4.2	4.1	4.1	4.0	4.1
2	-1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.6	3.1	3.6	4.1	4.1	4.0	4.0	3.8	3.6	3.4	3.2	3.0
1	-0.4	-0.2	0.0	0.6	1.1	1.7	2.3	2.9	3.4	4.0	4.0	4.0	4.0	4.0	3.5	3.0	2.5	2.0	2.0	2.0

	101	102	103	104	105	106	107	108	109	110	111	112	113
11	8.2	8.3	8.3	8.3	8.3	8.4	8.4	8.4	8.3	8.3	8.3	8.2	8.2
10	8.2	8.2	8.3	8.3	8.3	8.4	8.4	8.4	8.3	8.3	8.3	8.2	8.2
9	8.1	8.2	8.2	8.2	8.2	8.3	8.3	8.3	8.2	8.2	8.2	8.1	8.1
8	7.8	8.0	8.0	8.0	8.1	8.1	8.1	8.1	8.1	8.0	8.0	8.0	8.0
7	7.2	7.4	7.5	7.6	7.7	7.9	8.0	7.8	7.7	7.5	7.3	7.2	7.0
6	6.8	6.9	7.0	7.0	7.1	7.2	7.3	7.2	7.0	6.9	6.8	6.6	6.5
5	6.1	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.2	6.1	6.1	6.0
4	5.8	5.8	5.8	5.9	5.9	5.9	5.9	6.0	6.0	6.0	5.7	5.3	5.0
3	4.2	4.2	4.3	4.4	4.5	4.6	4.7	4.7	4.8	4.9	5.0	4.5	4.0
2	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	3.7	3.5	3.2
1	2.0	2.0	2.0	2.1	2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.0	2.6

APPENDIX 4B

GRAPHICAL ILLUSTRATION OF FRONTAL WIND SPEED PROFILES

In this appendix, the wind speed profiles which an aircraft would encounter approaching along a 3° glide slope through a cold synoptic front are illustrated. Four flight paths having 3° glide slopes and spaced at equal increments along the horizontal extent of the data set are shown in Figure 4B-1. Figures 4B-2 and 4B-3 illustrate the wind speed profiles along the four flight paths. One observes that the winds can be significantly different for aircraft approaching at different times through the same front. Due to the limited spatial extent of the data set the latter flight paths, 3 and 4, do not extend to the full 500 m level and consequently are only plotted to the height at which they pass out of the data set at the right-hand margin.

The streamlines on which the flight paths are drawn are based on wind speeds relative to the motion of the front which is 9.3 m s^{-1} and 7.1 m s^{-1} for Figures 4B-2 and 4B-3, respectively. The vertical dashed line on the longitudinal velocity profiles illustrate the mean motion of the front, $\overline{W}_x$.

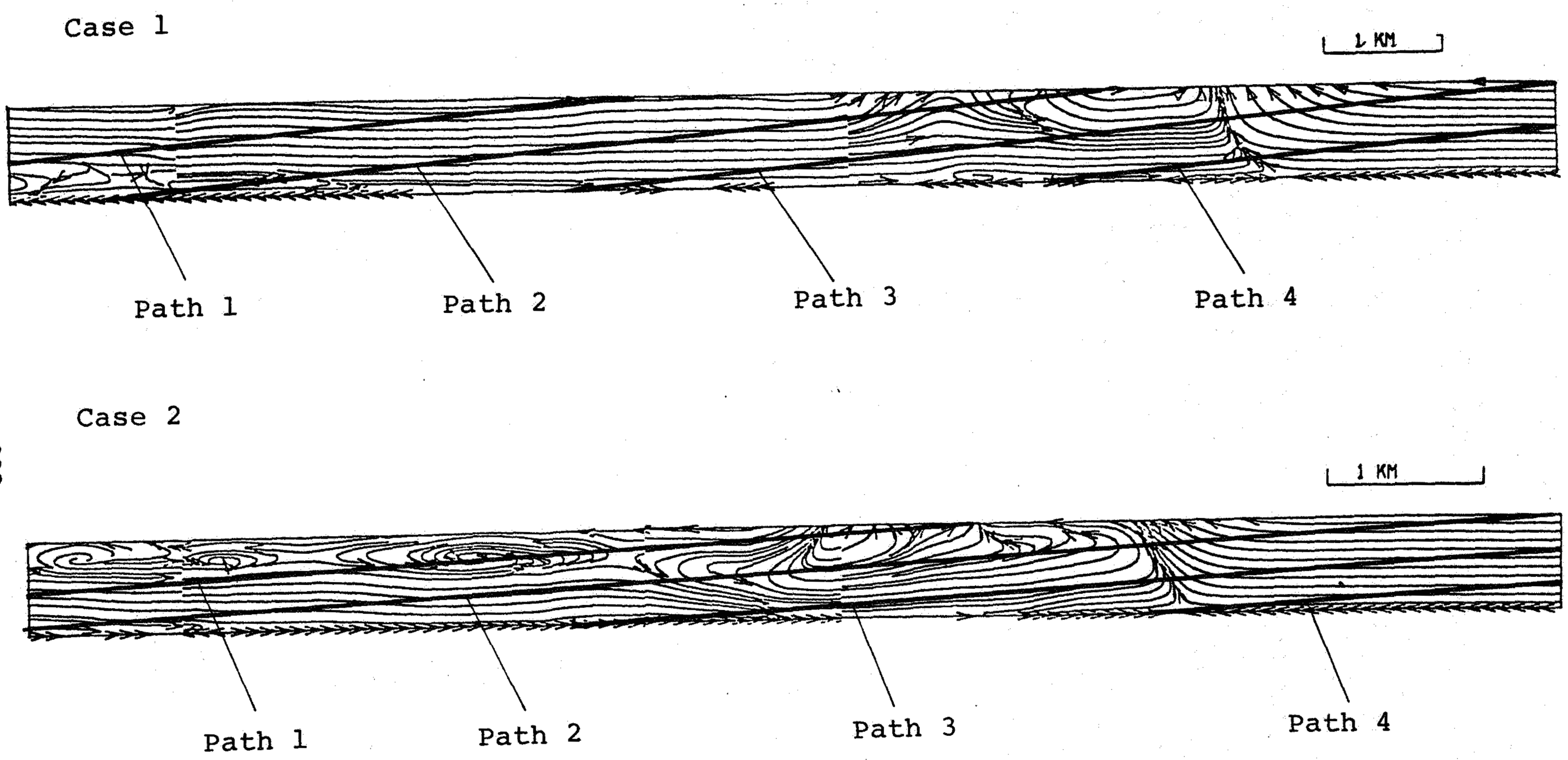

Figure 4B-1 Flight Paths through Streamline Pattern Moving with the Front Corresponding to Wind Speed Profiles in Figures 4B-2 and 4B-3

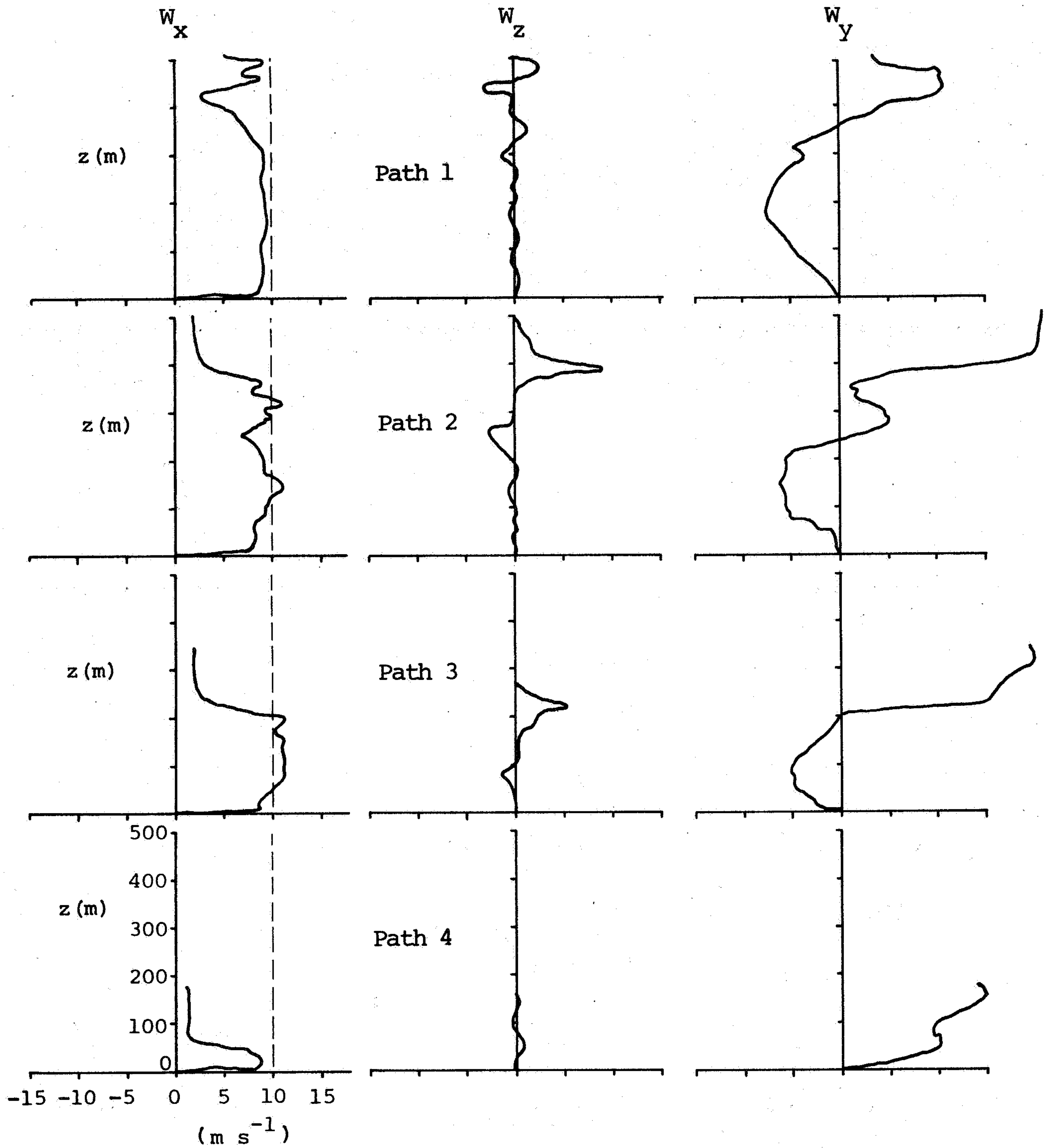

Figure 4B-2 Wind Speed Profiles Along Four Different Flight Paths Through Cold Front, Case 1

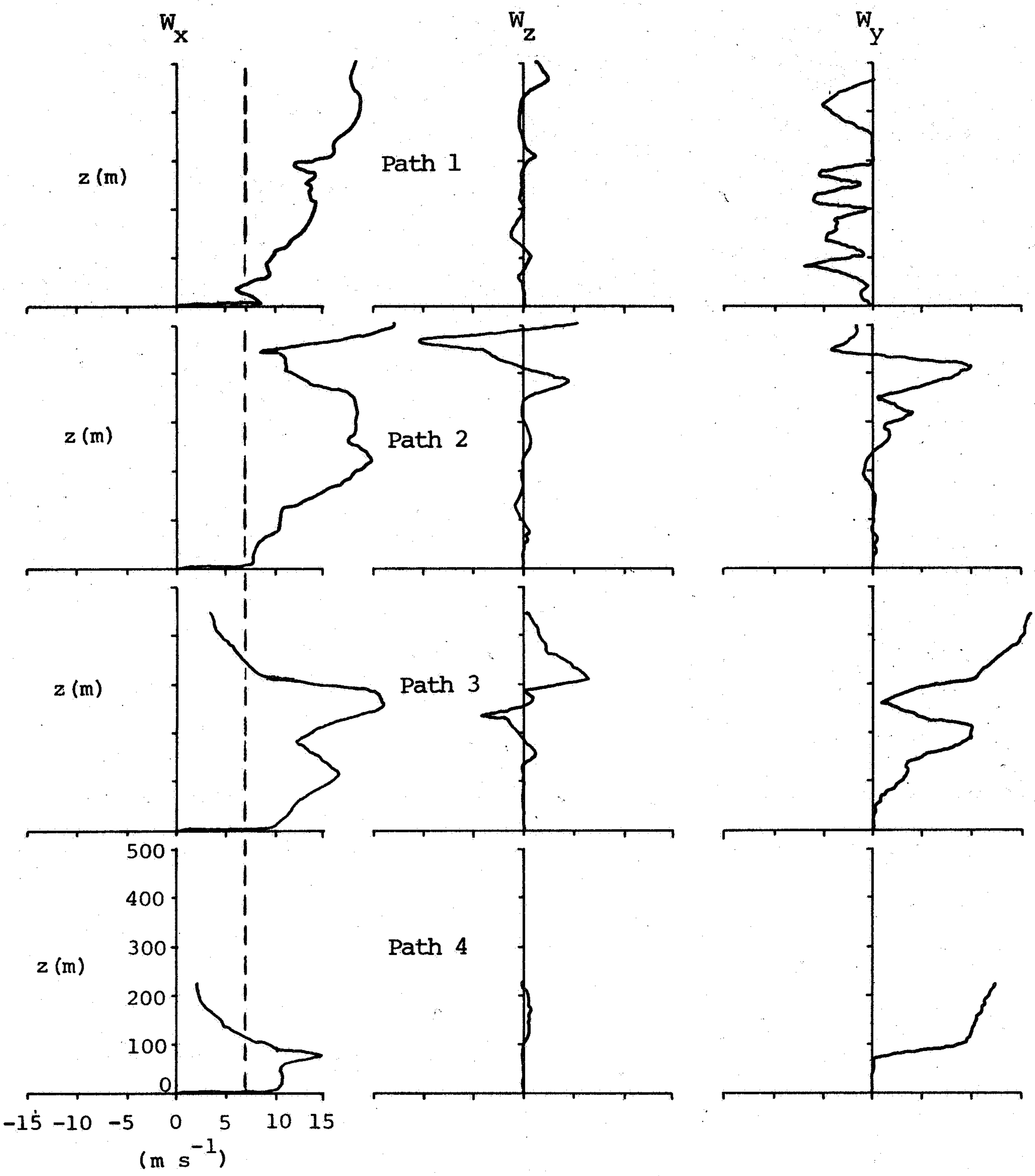

Figure 4B-3 Wind Speed Profiles Along Four Different Flight Paths Through Cold Front, Case 2