WIND CHARACTERISTICS FOR HAWAIIAN ELECTRIC COMPANY TRANSMISSION LINES ON OAHU-- PHYSICAL MODEL STUDY IN A BOUNDARY-LAYER WIND TUNNEL

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EXECUTIVE SUMMARY

This report presents data on wind characteristics obtained by physical modeling in the Colorado State University environmental boundary-layer wind tunnel using a 1:4,000 scale terrain model of complex terrain on Oahu. The physical modeling was limited to the most significant meteorological condition of strong, thermally neutral wind approaching the island. Strong winds are wind speeds in excess of 10 knots (22 mph) at 10 m above ground or sea level for which mechanical mixing due to turbulence is sufficient to make thermal effects on wind characteristics insignificant within the boundary layer (layer above sea or ground approximately 350 m in depth). Thermally driven mountain-valley winds were not modeled in this study. Data were measured along 15 HECO transmission-line valley crossings, at four field anemometer locations and at Honolulu International Airport (HIA) and Barbers Point Naval Air Station (BPA) anemometer locations. The specific valley crossings and the number of crossings for which data were measured are as follows: Waiawa-two; Waimano-two; Waimalu-five; Kalauao-two; North Halawa-two; South Halawa-one; and Moanalua-one (see Fig. 1-1 for locations). The primary information presented is mean and turbulent wind velocity data scaled with mean wind speed above the boundary layer $\bar{U}_{ref}$ for south (S), south southwest (SSW), southwest (SW), west southwest (WSW), north northeast (NNE) and east northeast (ENE) winds approaching Oahu. The tabulated data are presented in Appendix G of this report and are presented graphically in Appendices D, E and F to facilitate interpretation and use.

The data can be used to obtain predictions of prototype wind speeds at transmission-line locations for engineering design. These predictions for strong, thermally neutral winds are made by applying National Weather Service (NWS) data collected at either HIA or BPA, or by applying HECO field data collected at the four anemometer locations included in this study.

Wind directions from the 45° sector SSW to WSW cause the highest wind speeds perpendicular to the transmission-line spans. An extreme-value analysis of gradient winds (one-hour mean wind above the boundary layer) derived from NWS records taken at HIA and BPA revealed that the highest wind speeds for Oahu occur for wind directions in the same 45°

sector (SSW to WSW). Mean gradient wind speeds from the SE (not modeled) are also high; however, wind speeds at the transmission-line crossings for this direction are not expected to be larger than those measured for the wind directions modeled.

An analysis of the data resulted in a predicted value of 73 mph as the maximum expected one-hour, 100-year mean recurrence interval, horizontal component perpendicular to the spans evaluated in this study. This analysis was accomplished by combining the 100-year recurrence extreme one-hour, mean gradient wind speed of 86 mph from the SSW with the highest measured model data. The 86 mph wind speed was derived from NWS data. The model wind speed used for this estimate was the SSW perpendicular-to-span data at location B5 (Waiawa crossing). The total expected one-hour, 100-year recurrence resultant wind speed at that same location using the same NWS data and the three perpendicular wind components measured in the model at B5 is 76 mph. In the case where the design wind time average is different from the one-hour average as given in this report, the one-hour average wind speed must be converted to the required time average. As an example, the one-hour, 73 mph wind speed becomes 105 mph for a 10-second wind average using data from Durst as cited by Hollister (1970).

An additional comparison can be made between the wind speeds measured at transmission-line locations and at HIA. In the case noted above (location B5 for a SSW wind) the ratio is 1.8 for the perpendicular-to-span wind component at transmission-line height divided by the equivalent HIA wind speed at 21 ft above ground level (current NWS HIA anemometer height). In other words, the wind speed perpendicular to the span at location B5 would be 1.8 times greater than the wind speed measured at HIA during strong, thermally neutral wind conditions. The same ratio for the other spans showed that 11 out of 15 spans studied have a 1.5 or greater multiplier, and all the spans have a 1.3 or greater multiplier.

The model measurements made of wind characteristics at transmission-line locations in the complex terrain of Oahu have shown significant increases in wind speeds at the transmission-line sites compared to wind speeds measured upwind over flat coastal sites such as HIA. This information is important input for the design of transmission lines or any other structure to be located in complex terrain.

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LIST OF SYMBOLS AND ABBREVIATIONS

Symbol	Definition
E_i	voltage
Re	Reynolds number
$\overline{u^2}$	horizontal mean-square turbulence component perpendicular to the span
$\overline{uv}$	turbulent shear stress in the horizontal plane
$\overline{uw}$	turbulent shear stress in the vertical plane
$\overline{U}_{HIA}$	mean horizontal wind speed parallel to the wind direction under study at 21 ft above ground level at Honolulu International Airport
$\overline{U}_{ref}$	free-stream mean reference velocity
$\overline{U}_{\ell}$	mean horizontal wind speed component perpendicular to the span at location ℓ
$\overline{v^2}$	horizontal mean-square turbulence component parallel to the span
$\overline{V}$	mean horizontal wind speed component parallel to the span
$\overline{w^2}$	vertical mean-square turbulence component
$\overline{W}$	mean vertical wind speed component
X	x-coordinate direction
Y	y-coordinate direction
z	height above ground line
z_{ref}	free-stream reference height above ground level
Z	z-coordinate direction
α	wind profile power-law exponent
ϕ	vertical angle of rotation
θ	horizontal angle of rotation

Data Abbreviations

ELEV	distance of sampling location above ground level (agl)
U MEAN	normalized mean horizontal wind speed perpendicular to the span
U TURB	horizontal turbulence intensity perpendicular to the span
V MEAN	normalized mean horizontal wind speed parallel to the span
V TURB	horizontal turbulence intensity parallel to the span
W MEAN	normalized mean vertical wind speed
W TURB	vertical turbulence intensity

1. INTRODUCTION

1.1 Statement of Problem

As in other regions of the Southern Pacific, tropical cyclones create a natural hazard in the State of Hawaii. In some cases, strong winds have caused severe damage to power transmission lines across the mountainous terrain on Oahu. Information on the wind characteristics along transmission lines spanning valleys from ridge to ridge is a prerequisite to mitigate such loss. Unfortunately, because of complexity of the terrain, analytical and numerical methods for predicting local velocities at different points along the transmission lines are not available.

A wind-tunnel study for Hawaiian Electric Company (HECO) to provide wind data for use in the design of cross-valley electric transmission line supports and spans has been conducted in the Fluid Dynamics and Diffusion Laboratory at Colorado State University (CSU). The valley crossings of concern which comprise the central study area are located as shown on Fig. 1-1. This study area is approximately 3.7 miles north of Pearl Harbor, Hawaii. From Pearl Harbor the mountains rise from sea level to 2,800 ft elevation toward the northeast to the crest of the Koolau Range in a little over 7.5 miles horizontal distance. Valleys are oriented northeast-southwest parallel to the general terrain gradient. The terrain in the sampling area is very rugged.

Extended field measurement programs are invariably expensive and time consuming while laboratory simulations are relatively inexpensive and provide reliable data on wind characteristics over complex terrain. Recent research has shown that wind-tunnel simulation can replicate the atmospheric boundary layer (Cermak, 1971, 1975, 1982). Physical modeling

can reproduce wind patterns produced by the near neutral atmospheric shear layer flowing over complex terrain to within the inherent variability of the atmosphere to produce stationary results (Meroney, 1980).

This study had two main objectives:

(a) determination of wind characteristics including mean and fluctuating speeds along transmission lines spanning valleys on Oahu for use in wind load design; and

(b) correlation of wind characteristics at HECO transmission line sampling locations with strong-wind data recorded at nearby meteorological stations: Barbers Point, HECO field anemometers and Honolulu International Airport.

Objective (a) was met by physical modeling of strong, thermally neutral boundary-layer winds over a 1:4,000 scale model of the area in a boundary-layer wind tunnel. Strong winds are those in which mechanical mixing due to turbulence is sufficient to effectively destroy thermal effects within the boundary layer. Winds above 22.4 miles per hour (mph) usually satisfy this requirement.

Objective (b) was partially met by applying the data obtained in Objective (a) to an extreme wind statistical analysis of the HIA and BPA meteorological data. An analysis using HECO field anemometer data was not made because HECO field data was not available. However, the model data is now available for fifteen valley crossings and four HECO anemometer sites to establish mean wind and turbulence characteristics for several wind directions representative of northeasterly trade winds and of southwesterly kona winds.

1.2 Study Procedure

The physical model boundary-layer study of wind characteristics for HECO transmission lines on Oahu was divided into four phases: model

construction, data collection and flow visualization, data reduction and interpretation, and a comparison analysis of available field data from the National Climatic Center for Honolulu International Airport (HIA) and for Barbers Point Naval Air Station (BPA). The rationale for choosing the 1:4,000 model scale, material and construction technique is discussed in Section 2.1 below and in detail in Appendix A: Model Construction. A map of the model boundaries for each wind direction is shown in Fig. 1-2.

In order to collect a complete, three-dimensional set of mean and turbulent wind characteristic parameters, it was necessary to sample each measurement location twice for each wind direction. The first data sample was made with a standard (UV) cross-film anemometer in the horizontal plane which was used to measure the local mean horizontal wind direction and speed and the local horizontal turbulence intensities, both parallel and perpendicular to the mean flow. The local wind direction is affected by terrain features and is often different from the free-stream wind direction. Also the turbulent shear stress $\overline{uv}$ was measured with the UV cross-film anemometer to enable the coordinate rotation calculations for individual transmission line coordinates. The second sample, taken at the same location and height as the first sample, was made with a boundary-layer (UW) cross-film anemometer in the vertical plane. The UW anemometer was oriented into the local horizontal mean flow direction as determined by the previous UV anemometer measurement, and the local mean horizontal speed and turbulent intensity were again measured along with the vertical mean speed and turbulent intensity. Although a vertical turbulent shear stress $\overline{uw}$ measurement was made, it was not used for a vertical coordinate transformation since

the mean-wind vector for strong winds never exceeded a 10-degree slope above or below the horizontal plane. Ten degrees was considered the limit for valid data acquisition for the UW cross-film anemometers. Either the UV or the UW anemometers are also referred to as X-probes in this report.

Two data-collection strategies were used: one for reference points and/or anemometer locations and one for transmission-line measurements. In all cases, the anemometer location data collection consisted of vertical profiles of wind data measured from the surface to the free-stream height. Profiles at either HIA or BPA were made for each wind direction along with profiles for HECO anemometer locations AN21, AN37, AN84, and AN86. Refer to Fig. 1-1 for the location of these points with the exception of BPA, which lies approximately 12 miles west of HIA and is off the map in Fig. 1-1. Two additional approach flow profiles were taken: one at the Koolau ridge crest and one upwind of Oahu for the ENE wind direction. The purpose of these profiles was to determine the boundary-layer behavior over Oahu during an ENE wind.

The second strategy used to provide wind information for transmission-line wind loads, was directed at obtaining representative wind data at the height of the transmission line. To accomplish this, three-dimensional mean and turbulent intensity wind data were sampled for each span: at the end points of each span, which corresponded to the ridge-top towers; at the two quarter points of each span; and at the midpoint of each span.

Qualitative information on overall flow characteristics was obtained by flow visualization using smoke as a tracer. Information obtained in this manner was recorded on video tape as a supplement to this report.

2. EXPERIMENTAL FACILITIES AND DATA ACQUISITION

2.1 Brief Summary of Oahu Terrain Model and Facilities

2.1.1 Oahu Terrain Model

The topographic model for this study was constructed to a 1:4,000 scale for both horizontal and vertical directions. This corresponds to approximately 1/8-in. for each 40 ft in elevation. According to recent studies by Neal (1983), the accurate simulation of complex terrain in a wind tunnel requires close attention to the following:

a) type of model surface finish;

b) selection of a suitable model scale;

c) tunnel blockage effects; and

d) the approach flow characteristics.

All of the above factors were carefully considered for this study.

The choice of 1:4,000 for the length scale was dictated by the spread of the actual sites for which data is required, the size of the wind tunnel employed, and the desire to acquire meaningful wind data for full-scale applications. All the span and HECO field anemometer locations of interest fall within a circle 9 miles in diameter. The CSU Environmental Wind Tunnel has a cross section width of 12 ft which scales to 9 miles at 1:4,000. The highest model terrain is about 9 in. corresponding to 3,000 ft (actually 2,826 ft).

A detailed description of Oahu terrain model construction is given in Appendix A. The completed model installed in the wind tunnel is shown in Fig. 2-1.

2.1.2 Experimental Facilities

The Environmental Wind Tunnel (EWT) which is located in the Fluid Dynamics and Diffusion Laboratory at Colorado State University was used

for this neutral flow study. Plan and elevation views of the wind tunnel are shown in Fig. 2-2.

The EWT was designed specifically to study atmospheric flow phenomena. The tunnel is an open-circuit facility with a 2.25-to-1 contraction ratio driven by a 50 hp variable-pitch, variable-speed fan. The test section is 52 ft in length and 12 ft x 8 ft in cross section. The wind speed in the test section can be adjusted continuously from 0.2 to 50 ft/sec and the ceiling is adjustable in height for control of the pressure gradient. This wind tunnel is also equipped with transparent side walls and rotating turntables.

A probe traversing mechanism was employed so that the vertical displacement could be controlled independently from outside the tunnel. The probe position was correlated with a digital voltmeter to give a resolution of 0.15 mm.

2.2 Velocity Measurements and Model Boundary Layer

Prior to collecting velocity measurements, the tunnel-ceiling height was adjusted and tailored to the terrain variation of each wind direction to cancel any longitudinal pressure gradient caused by the presence of the model. A mean velocity profile for flow approaching Oahu (the approach velocity profile) was taken prior to any turbulence measurement. The approach flow boundary-layer conditions were set to give a 15 cm model boundary-layer depth corresponding to a 2,000 ft (600 m) prototype boundary-layer thickness for all wind directions. A pitot-static tube was placed at the upper edge of the boundary layer to continually monitor the reference velocity during data acquisition.

Mean velocity and turbulence intensity profiles were measured with both UV and UW cross-film anemometer probes (X-probe). A discussion of

hot-film anemometry briefly introduced in Section 1.2 is presented separately in Appendix B.

During data collection the X-probes were calibrated daily or more frequently as required. The ambient air temperature within and surrounding the EWT facility was maintained within a range of ±1°C after calibration. The error associated with temperature drift in this range is less than 0.3 percent with respect to voltage output from the anemometer.

In hot-film anemometry it is necessary for accurate measurements to point the UW X-probe parallel to the mean flow within ±10°. It was observed from the flow visualization (and verified with measurements) that the vertical angles between the mean flow and horizontal plane were typically less than 10° for all preselected measurement locations. Therefore, it was not necessary to adjust the probe for vertical angles since ±10° is within the tolerance of UW X-probe operation. As discussed in Section 1.2, for each measurement, the UV X-probe was first employed to measure velocity components in the horizontal X-Y plane. These UV velocity components were used to determine the local mean wind direction (horizontal angle). The UW X-probe was then positioned at that same location with the known horizontal angle to measure velocity components in the vertical X-Z plane. A sampling problem associated with taking near-surface wind data and profiles on this rough terrain model was due to the sloping terrain. In some cases it was difficult to position the "J" shaped UW X-probe close enough to the surface. It was necessary to leave a safety clearance from the model surface to avoid damage to the probe. Hence, a 0.20 cm (26.2 ft in prototype) height was the closest distance to the ground allowed in the present study.

The approach velocity profile for the south wind was taken 12,000 ft south of the Honolulu International Airport (HIA). The result is presented in Appendix D, Fig. D-1. The data in Fig. D-1 as well as all the data in this report are normalized by a reference velocity measured simultaneously above the boundary layer (see Section 2.4.3 and Appendix C for further details). The approach velocity profile presented in Fig. D-1 almost matches with the velocity profiles taken at the HIA as shown in Appendix D, Figs. D-2, D-7, D-12, and BPA shown in Fig. D-17. These velocity profiles are equivalent to a 0.15 power law velocity profile with boundary-layer thickness of 2,000 ft.

Turbulence intensities measured at HIA for the south wind are presented in Appendix D, Fig. D-2. Figures D-7 and D-12 show the velocity profile measured at HIA for south-southwest and southwest wind directions. Upwind of the terrain, the approach velocity profile remains the same for all wind directions.

2.3 Flow Visualization Techniques

Smoke was used for the flow visualization study. The smoke was produced by exposing titanium tetrachloride saturated cotton swabs to the air flow. In order to visualize effectively the flow pattern, wind speeds had to be reduced from 30 ft/sec to approximately 13 ft/sec. In addition to the flow visualization still photos were taken with a Speed Graphic camera utilizing Polaroid film. Additional still pictures were obtained with a 35 mm single lens reflex (SLR) camera. A Panasonic video camera was used with instantaneous playback on a color TV for the flow visualization video. The video consists of close-ups of the flow pattern at span and anemometer locations and general views of the flow pattern over the model. The viewer must refer to the yellow letters and

numbers on the green model in order to determine location. A red arrow is used to indicate free-stream wind direction. Figure 2-3 shows flow down the valley for the east-northeast wind direction.

2.4 Data Reduction and Format

2.4.1 Wind Characteristics Data at Field Anemometer Locations

For the six wind directions as shown in Fig. 1-2, mean wind velocity and turbulence intensity profiles were measured at the following locations:

1. Barbers Point Naval Air Station (WSW and ENE directions only--others not measurable)
2. Honolulu International Airport (except WSW and ENE--not measurable)
3. HECO Anemometer locations AN21, AN37, AN84 and AN86.

Wind characteristics measured at these locations are reported using the geographical coordinate system discussed in Appendix C. Not all airport anemometer sites are represented with data for each wind direction because one of the sites was either beyond the model for some wind directions or because a site was so close to the EWT side wall boundary that the flow was distorted and thus the measurement would have been meaningless.

2.4.2 Wind Characteristics Data Along Transmission Lines at Valley Crossings

Fifteen valley crossings (spans) were studied. These are identified in Table 2.1. Locations of HECO anemometer sites and valley crossings are shown in Fig. 1-1.

As discussed in Section 1.2 measurements of mean wind velocity and turbulence intensity profiles at valley crossings were taken at the following span locations:

1. Both end supports,
2. Quarter-span points, and
3. Mid-span.

The vertical profile at each location consisted of up to five or more points. The range in measurement height covered the range of transmission-line height above ground level resulting from field temperature variations. Ideally, transmission-line point profiles were made as follows:

Span Location	No. of Data Points	Vertical Separation between Data Points
Mid-span	5	50 ft
Quarter-span	5	50 ft
End point (tower support)	4	50 ft

At mid-span points and at quarter-span points, measurements at two points above and two points below the transmission line were obtained in addition to a point at the transmission-line elevation. At the end-point towers, measurements at two points above and one point below the transmission line were obtained in addition to a point at the transmission-line elevation. Wind characteristics measured at these locations are presented graphically in Appendix E and tabulated in Appendix G using the transmission-line coordinate system discussed in Appendix C. Table 2.2 identifies the code names used for the data and Section 2.4.3 below describes the data listing in Appendix G.

The sampling points for each of the transmission-line spans were named according to letter names originally determined by HECO as given in Table 2.1 and according to their location along the span relative to North. For instance, the five sampling locations on span B are named B1

for the northern-most tower point, B2 for the first quarter location south of B1, B3 for mid-span,. B4 for the second quarter location, and B5 for the southern-most tower for span B. In the case where one span ends and another starts, the end name of the northern-most span prevails. For instance, span G is north of span J, therefore G5 is the same location as J1; in this case G5 is used and the name J1 is not used. Table 2.2 gives the span and point name, span azimuth (measured clockwise from north), approximate terrain height beneath the measurement location referred to mean sea level (msl), the approximate transmission line height referred to msl, and approximate ground-to-transmission line distance (i.e., location of the transmission line above ground level (agl)).

Span azimuths, terrain heights and transmission-line heights were extracted from HECO Plan and Profile Drawings. The HECO Plan and Profile Drawings used assumed elevations for vertical transmission line position of valley crossings. Some differences may exist in the relative terrain heights between the USGS map (which was used for model construction) and HECO Plan and Profile Drawings. Measurement difficulties were minimized by using the following procedures:

1. For the support tower heights (both end supports) of the transmission line, transmission-line height was adopted from the HECO Plan and Profile Drawing. In the cases where no height was given, 35 ft was used.
2. For the quarter-span and mid-span points, transmission-line height was measured relative to the USGS map ridge height and linearly scaled to the model using the HECO Plan and Profile line catenary.

The total number of wind data sets sampled for HECO transmission lines on Oahu are summarized in Table 2.3. Data missing in this table are discussed in Section 3.4.

Actual data collection was accomplished in the following order of directions: S, SW, SSW, WSW, ENE and NNE. It was discovered early on that there was little variation in wind speed with height immediately above or below the transmission line height. For examples see Figs. E-10, E-76, E-86, E-96, E-132 and E-133 for wind directions S, SSW, SW, WSW, NNE and ENE respectively. Therefore, an attempt was made to eliminate redundant sampling heights and locations for successive wind directions.

2.4.3 Description of Wind Characteristics Data in Appendix G

The data are presented in eight columns which give (all velocities and turbulence values are normalized by $\bar{U}_{ref}$): the data location code name; height above prototype ground level; mean horizontal speed perpendicular to the span; mean horizontal speed parallel to the span; vertical mean speed; horizontal turbulence intensity perpendicular to the span; horizontal turbulence intensity parallel to the span; and vertical turbulence intensity, respectively. The following is a detailed description of the data in each column.

Column 1: Data code name: NAME

The data code name is a five-letter/digit code which identifies the data location. Table 2.2 gives the data code name for each sampling point. The locations of cable spans and HECO anemometers are presented in Fig. 1-1. Figure 1-1 includes the HIA data reference location.

The second element in the code name is the wind direction indicator: D=5 represents the south wind direction and D=1 represents

the southwest wind direction. The last element in the name code indicates the data point number for that particular location. This is used to indicate different elevations. For instance, the lowest height measurement is indicated by a zero, the next highest by a 1, and so on.

Column 2: Height above prototype ground level: ELEV

The height in feet above ground level (agl) of each data point is presented in the second column. To identify the corresponding transmission-line height above ground level refer to Table 2.2.

Column 3: Normalized mean horizontal wind speed perpendicular to the span: U MEAN

This column presents the mean horizontal wind speed component perpendicular to the span at the indicated location and height. It is normalized by the free-stream reference wind speed; i.e. $\bar{U}/\bar{U}_{ref}$ (see Appendix C). The span azimuths are listed in Table 2.2.

Column 4: Normalized mean horizontal wind speed parallel to the span: V MEAN

This column presents the mean horizontal wind speed component at the indicated location and height parallel to the span. It is normalized by the free-stream reference wind speed; i.e. $\bar{V}/\bar{U}_{ref}$ (see Appendix C).

Column 5: Normalized mean vertical wind speed: W MEAN

This column presents the mean vertical wind speed component at the indicated location and height. It is normalized by the free-stream reference wind speed; i.e. $\bar{W}/\bar{U}_{ref}$ (see Appendix C).

Column 6: Horizontal turbulence intensity perpendicular to the span: U TURB

This parameter is the horizontal turbulence component perpendicular to the span; i.e. $(\overline{u^2}/\overline{U^2_{ref}})^{\frac{1}{2}}$ (see Appendix C).

Column 7: Horizontal turbulence intensity parallel to the span: V TURB

This parameter is the horizontal turbulence component parallel to the span; i.e. $(\overline{v^2}/\overline{U^2_{ref}})^{\frac{1}{2}}$ (see Appendix C).

Column 8: Vertical turbulence intensity: W TURB

This parameter is the vertical turbulence intensity perpendicular to the span; i.e. $(\overline{w^2}/\overline{U^2_{ref}})^{\frac{1}{2}}$ (see Appendix C).

3. RESULTS AND DISCUSSION

3.1 Similarity Criteria and Reynolds Number Independence Test

Similarity requirements for physical modeling of flow in the atmospheric boundary layer have been discussed by Chuang and Cermak (1967), Méry (1969), Cermak and Arya (1970) and Cermak (1971, 1975). Generally speaking, the following criteria for modeling are derived from the equations for conservation of mass, momentum and energy: (1) geometric similarity, (2) thermic similarity, (3) dynamic similarity, and (4) kinematic similarity.

Geometric similarity was achieved in the present study by using an undistorted model with a scale of 1:4,000 for both horizontal and vertical directions. Flow in the wind tunnel was uniform in temperature to simulate thermal stability associated with strong winds.

Dynamic similarity is achieved in a strict sense if the Reynolds number and Rossby number are the same in the model and prototype. The Rossby number is a measure of the effect of Earth's Coriolis force relative to the inertial forces on the flow field. In the wind tunnel equal Rossby number between model and prototype cannot be achieved unless the wind tunnel itself is rotated. However, local mean velocities in flow around and immediately above rough complex terrain are

governed by shear stresses and local pressure gradient induced by the geometry. These effects are strong compared to Coriolis effects. Accordingly, relaxation of Rossby number equality is considered an approximation that does not introduce significant error in simulation of flow over complex terrain (Cermak, 1971, 1975, 1984). Kinematic similarity requires the scaled equivalence of streamline patterns of air flow over model and prototype. Therefore, the Reynolds number (Re) criterion is a significant parameter in physical modeling of atmospheric boundary-layer flow. The Reynolds number indicates the ratio of inertial to viscous forces. Equal Reynolds numbers are not attainable in the laboratory due to the large scale factor usually adopted. Fortunately, this is not a serious limitation for higher wind speeds since flow characteristics will be dynamically and kinematically similar when the surface becomes aerodynamically rough regardless of increases in Reynolds number (Schlichting, 1975); i.e., the local flow characteristics become independent of Reynolds number if a lower limit of the Reynolds number is exceeded (Cermak, 1975).

Reynolds Number Independence Test

Figure 3-1 shows that the normalized mean velocity and normalized turbulence intensity are essentially Reynolds number independent in this case for Re exceeding 5×10^4 which is equivalent to a mean velocity of 16.5 ft/sec. All span and anemometer wind data measurements for this study were acquired at a free-stream velocity of 30 ft/sec; therefore, the modeled flow characteristics for Oahu are considered Reynolds number independent and can be scaled for prototype predictions and comparisons.

3.2 Flow Visualization Results

Figure 3-2 shows the Oahu model and experimental instrumentation. Flow visualization for all six wind directions were recorded on color

slides and videotape. Detail information at each span location can be observed on the videotape. Changes of wind direction versus height may be observed at each location by viewing the videotape.

For the S and SSW wind directions, the valley orientations are approximately 40 degrees to the mean wind flow. In these cases, flow separations typically occur at the lee-side quarter-span points for the deeper valleys. Due to the flow separation the wind data is erratic, mean wind directions are unpredictable and turbulence intensities are high for these quarter-span points. The near surface streamline patterns (i.e. wind flow) are determined by ridge-line orientation such that the local mean wind directions within valleys are identical with the valley orientations. With height increases above ground level, the local mean wind direction gradually returns to the free-stream wind direction.

The Koolau Range created a large flow separation region for the NNE and ENE wind directions that engulfed all of the transmission line crossings. This flow condition resulted in uniformly lower wind speeds and high turbulence intensity over the entire region of study. Table 3.1 lists the maximum normalized mean horizontal perpendicular wind speeds (U MEAN) by wind direction at transmission line height. This table verifies that the NNE and ENE wind directions result in relatively lower U MEAN values compared to the other wind directions.

For the WSW and SW wind directions, the surface flow tended to follow the direction of the valley. Flow separation regions were minimal or nonexistent for the WSW wind because the valley/ridge terrain features are parallel to wind approaching the area.

3.3 Anemometer Location Data

Appendix D contains the vertical profile plots of the anemometer and reference points data. Profiles taken upwind of the model are all very similar and simulate a thermally neutral boundary layer of 2,000 ft quite well. The mean horizontal wind speed at any upwind reference height, z, can be calculated using the power-law exponent $\alpha = 0.15$ and free-stream height $z_{ref} = 2{,}000$ ft in the wind-profile equation

$$\frac{\bar{U}}{\bar{U}_{ref}} = \left[\frac{z}{z_{ref}}\right]^{\alpha}$$

HECO anemometer location profiles within the complex terrain show the terrain caused profile distortions (wind speed deficits) in the lower boundary layer adjacent to the ground as seen in Appendix D, Figs. D-3, D-4, D-5, D-8, D-9, D-19, D-20, D-21, and particularly Figs. D-22, D-23, D-24, D-25, D-28, D-29, D-30, D-31, and D-32 for the ENE and NNE directions. It should be noted that Fig. D-27, the BPA reference profile for the ENE direction, appears normal since it is an additional 12 miles downwind of the transmission line sampling area and does not represent the boundary layer over the transmission line sampling area.

The power-law exponent, α, for HIA for the NNE and ENE cases with the Koolau Range upwind is about 0.09 and z_{ref} about 4,600 ft; for the other wind directions use 0.15 and 2,000 ft for α and z_{ref}, respectively.

3.4 Transmission-line Data

Transmission-line data are presented in tabular form in Appendix G. Table 2.1 and Fig. 1-1 are required to locate individual data points. Section 2.4.3 describes the data in Appendix G. Data comparisons between points and spans can be made by either extracting the information from

Appendix G or by comparing the transmission-line point profiles, plotted and presented in Appendix E and by comparing the cross-span mean velocity plots plotted and presented in Appendix F. The latter figures are useful for representation of total wind load across individual spans.

As observed during the flow visualization, when the Koolau Range was positioned upstream of the sampling region for the NNE and ENE wind directions, lower wind speeds and higher turbulence intensities over all span locations were measured. For these two directions, velocity measurements were only made at a few representative span locations in addition to the regular anemometer profiles. As discussed in Section 3.3, Figs. D-22 through D-32 (Appendix D) show that the mean wind speeds are lower than their counterparts for other wind directions (e.g. SSW clockwise through WSW wind directions).

In some cases there are data points missing in Appendix G. The data missing is either the mean vertical speed (i.e. $\bar{W}/\bar{U}_{ref}$ listed as W MEAN in Appendix G), the horizontal component of turbulence parallel to span $(\overline{(v^2)}^{\frac{1}{2}}/\bar{U}_{ref}$ listed as V TURB in Appendix G), or the vertical component of turbulence $(\overline{(w^2)}^{\frac{1}{2}}/\bar{U}_{ref}$ listed as W TURB in Appendix G). All the remaining data points: $\bar{U}/\bar{U}_{ref}$ (listed as U MEAN in Appendix G); $\bar{V}/\bar{U}_{ref}$ (listed as V MEAN in Appendix G); and $\overline{(u^2)}^{\frac{1}{2}}/\bar{U}_{ref}$ (listed as U TURB in Appendix G) are complete in Appendix G. As discussed previously, data collection for each point was accomplished by taking two separate measurements. In some cases either only one of the two measurements were taken or the data were determined invalid. In these cases there is no entry in either the W MEAN and W TURB, or in the V TURB columns. In all cases, the mean horizontal data, which is the most important for neutral flow correlations with National Weather Service data, are tabulated in Appendix G.

3.4.1 Vertical Profiles at Locations Along Transmission Lines

Mean velocity and turbulence intensity profiles at locations along transmission lines are presented in Appendix E.

Appendix E does not include profiles with less than three data points. One should refer to Appendix G for the complete data set which includes transmission line data for sampling points where less than three elevations were sampled.

3.4.2 Cross-span Plots of Wind Data

Mean wind speeds at transmission line height for span crossings are plotted in Appendix F. A negative sign preceding a mean wind speed indicates the wind comes from the negative direction of the transmission-line coordinate which is based on the transmission-line azimuth. It appears that the SSW clockwise through WSW winds result in strongest impacts on transmission lines. The wind flow becomes more and more complex as the wind azimuth approaches 180° (S wind) where the ridge and valley systems are oriented between 40° to 70° to the approaching wind. The mean wind speeds were significantly reduced for NNE and ENE wind directions because the high Koolau Range mountain provides a barrier for the region of study.

For any particular wind direction the transmission-line data results plotted in Appendix F and tabulated in Appendix G show that the perpendicular-to-span, U MEAN, results are highly correlated to the valley orientation, valley depth, and transmission-line azimuth. As an example, compare the SW direction U MEAN plot of span H in Fig. F-36 with the SW direction U MEAN plot of span J in Fig. F-38. Span J is a relatively shallow transmission-line crossing compared to span H. In Fig. F-36 the U MEAN speed is higher at mid-span, while in Fig. F-38 the

U MEAN speed is lower at mid-span. The valley orientation at H is SW while the valley orientation at J is 15° more to the west.

Although it is not within the scope of this study to analyze the measurements, some interesting implications and focii for future study can be made after a cursory inspection of the normalized horizontal mean flow perpendicular to the span (U MEAN). Maximum U MEAN values which are dependent on transmission-line azimuth are listed in Table 3.1 for transmission-line height data where U MEAN equaled or exceeded V MEAN. When the free-stream wind flow was not near parallel to the valley orientation (S, NNE and ENE), the maximum wind speed perpendicular to the transmission line usually occurred at the span end points located at the ridge tops. When the free-stream flow was nearly parallel to valley orientation (SSW, SW and WSW), maximum perpendicular speeds usually occurred at quarter- or mid-span locations. The maximum normalized perpendicular wind speed for this study was 0.85 which occurred for the SSW wind direction at location B5. This maximum value was followed by values of 0.81 for points C5 and N3 during a WSW wind, and 0.80 for points G3 and P2 for a SW wind. An application caution should be noted here: the end points of each span would also be impacted by the parallel wind component. Since the end supports are vertical, wind loading will be maximum for the resultant horizontal wind.

4. EXTREME WIND STATISTICS

Two wind-speed recording stations are available in the Honolulu area which can be used to establish extreme wind statistics: Honolulu International Airport and Barbers Point Naval Air Station (BPA). HIA is marked on Fig. 1-1 and BPA is located approximately 12 mi west of HIA.

Three sets of data are available from the National Climatic Data Center in Asheville, North Carolina. The data available were:

1. HIA--Fastest mile wind speeds each year from 1951-1979 for 8 wind directions at anemometer heights ranging from 21 ft to 93 ft.
2. BPA--Peak gust wind speeds each year from 1949-1983 for 16 wind directions at anemometer heights of 12 or 84 ft.
3. HIA--29,215 hourly observations from 1965-1974 at 25 ft elevation in the form of a bivariate distribution of wind frequency as a function of wind speed and 16 wind directions. Hourly observations consist of one-minute means obtained once each hour--assume these to be the one-hour mean.

Fastest mile or peak gust data (data sets 1 and 2) were first translated to a common 10 m height. The wind data for each direction were then fit to a Type I extreme value distribution to predict 10-, 50-and 100-year recurrence winds at 10 m. These values were converted to one-hour mean winds and translated to gradient height. Tabulations are shown in Table 4.1.

The hourly data at Honolulu (data set 3) were fit to a Weibull probability distribution for each wind direction. The resulting distributions were extrapolated to obtain predictions of 10-, 50- and 100-year wind speeds. Data were translated to gradient level for comparison with fastest-mile and gust-data predictions. Results are listed in Table 4.1.

The lengths of record for data sets 1 and 2 would indicate that predictions at a 50-year recurrence interval might be within about 10 percent--this comparability was satisfied for data sets 1 and 2 except at the NE direction where upwind terrain is somewhat different for the two sites. The shorter record for data set 3, which is also a set of data from the parent distribution rather than data from an

extreme distribution as in data sets 1 and 2, would imply larger uncertainty at 50- and 100-year recurrence interval than would exist for the longer records. Variability in predicted 100-year winds for data set 3 does seem to be larger.

The extreme value distribution used for data sets 1 and 2 is known to converge from above for short records (30-50 years is a short record for these distributions). This means that the predicted wind speeds for 50- or 100-year winds are more likely to be higher than the true value than to be lower. A tendency is evident in Table 4.1 for the extreme value results (data sets 1 and 2) to be higher than the results from the parent distribution (data set 3).

Several possibilities exist for selecting a design wind speed from Table 4.1. The most conservative approach is to pick the largest wind speed appearing at each wind direction for the recurrence interval selected. Another possibility is to average the predictions at each wind direction. A third possibility is to ignore the data of Table 4.1 in favor of wind speeds which might be expected from a hurricane. Because hurricane winds occur at widely spaced intervals in time, they are not well represented in the short records available. For many east coast U.S. locations, hurricane wind speeds predicted from a hurricane model are substantially larger for 50- and 100-year winds than those predicted using analysis similar to that leading to Table 4.1. Whether or not hurricane wind speeds dominate for 50- or 100-year winds on Oahu is not known and is beyond the scope of this investigation.

5. DATA APPLICATION GUIDANCE

This section presents a straightforward technique for the application of model wind data with HIA or BPA meteorological data. To

estimate a field mean wind speed comparison at any location the corresponding normalized model data point representing $\bar{U}/\bar{U}_{ref}$, $\bar{V}/\bar{U}_{ref}$ or $\bar{W}/\bar{U}_{ref}$ must be multiplied by a model conversion factor $\bar{U}_{ref}/\bar{U}_{HIA}$ (discussed in Appendix C) and by the HIA speed of interest:

$$\bar{U}_{field} = \left[\frac{\bar{U}}{\bar{U}_{ref}}\right] \times \left[\frac{\bar{U}_{ref}}{\bar{U}_{HIA}}\right] \times (\text{HIA speed})$$

$$\begin{matrix}\text{(desired} \\ \text{estimate)}\end{matrix} = \begin{matrix}\text{(normalized} \\ \text{model data)}\end{matrix} \times \begin{matrix}\text{(model to field} \\ \text{conversion factor)}\end{matrix} \times \begin{matrix}\text{(Nat.Weather} \\ \text{Serv. Data)}\end{matrix}$$

The $(\bar{U}_{ref}/\bar{U}_{HIA})$ conversion factor for S, SSW, SW, and WSW winds is 2.0 corresponding to a power-law exponent of 0.15 and free-stream height of 2,000 ft; and 1.6 for ENE and NNE winds corresponding to a power-law exponent of 0.09 and free-stream height of 4,600 ft. These conversion factors are based on the HIA anemometer height of 21 ft.

As an example consider the maximum modeled data point discussed in Section 3.4.2: From Appendix G for location B5, U MEAN is 0.85, V MEAN 0.25, and W MEAN -0.01 for a SSW wind. If, for example, a wind speed of interest measured at HIA (21 ft agl) for a SSW wind is 25 mph, the estimated horizontal perpendicular-to-span wind at location B5 would be 43 mph:

$$\bar{U}_{B5} = 0.85 \times 2 \times 25 = 43 \text{ mph} \quad .$$

Similarly, the estimated parallel and vertical components would be 13 mph and -0.5 mph (downward vertical direction) respectively. Combining the three directions vectorially provides an estimated speed of 45 mph for the example case.

Care should be taken when making the above calculations to insure that the synoptic meteorological conditions come close to those modeled

in the tunnel; i.e., a strong wind, with thermally neutral stratification, from the proper direction. It is advisable to seek the guidance of a meteorologist familiar with such comparisons.

The extreme wind statistics provided in Section 4.0 can be applied directly to the model wind data to predict expected extreme wind speeds. Select the gradient wind speed statistic of interest from Table 4.1 and multiply it by the model wind data in Appendix G for the location of interest. For example, a prediction of the highest SSW 100-year wind speed at location B5 under neutral atmospheric conditions can be obtained as follows. Table 4.1 gives, for the the SSW direction, the highest 100-year gradient wind speed as 86 mph (data set 2). This value is then multiplied by the $\bar{U}/\bar{U}_{ref}$, $\bar{V}/\bar{U}_{ref}$ and $\bar{W}/\bar{U}_{ref}$ data for B5:

$$\bar{U}_{field} = \left[\frac{U}{\bar{U}_{ref}}\right] \times \text{(Extreme gradient wind speed)}$$

$$\begin{matrix}\text{(desired} \\ \text{estimate)}\end{matrix} = \begin{matrix}\text{(normalized} \\ \text{model data)}\end{matrix} \times \begin{matrix}\text{(Table 4.1 extreme} \\ \text{gradient wind speed)}\end{matrix}$$

$$\bar{U}_{B5} = 0.85 \times 86 = 73 \text{ mph} .$$

Similarly, $\bar{V}_{B5}$ and $\bar{W}_{B5}$ are 21 mph and -1 mph respectively, making the total predicted 100-year vector speed at B5 76 mph. The above calculation does not represent the maximum resultant 100-year transmission-line wind speed during the thermally neutral strong wind conditions modeled in this study but only the maximum perpendicular-to-span value.

6. SUMMARY

This report presents wind characteristics data obtained using a 1:4,000 scale model of HECO transmission-line locations on Oahu for

strong, thermally neutral winds approaching Oahu. Thermally driven winds (up-slope, down-slope, anabatic, catabatic, sea-breeze, and land-breeze) and winds occurring with unstable and stable atmospheres were not modeled in this study.

The data collected can be used to make engineering estimates of correlations between HIA and BPA NWS data and HECO Oahu field data for strong, thermally neutral winds. The model wind data shows that the SSW clockwise through WSW directions give the highest normalized wind speeds perpendicular to the spans studied. The extreme gradient wind statistical analysis also showed the same SSW clockwise through WSW wind directions as measured at HIA and BPA to have the highest predicted mean gradient extreme winds. The SE direction which was not modeled also has high predicted mean gradient extreme winds; however, winds at the transmission-line crossings are not expected to be larger than those measured for the wind directions studied based on data in Table 4.1.

Combining the SSW extreme mean gradient 100-year recurrence wind statistics of 86 mph with the highest measured SSW perpendicular-to-span model data at location B5 gave a predicted value of 73 mph as the maximum expected one-hour mean 100-year horizontal perpendicular-to-span wind speed. The total expected 100-year recurrence vector wind speed at that location was 76 mph. It was pointed out that although this value may be the highest modeled perpendicular-to-span wind it is not necessarily the highest total wind vector at span height.

The transmission-line data presented herein is highly dependent upon the model conditions stated above, the reference wind direction, the orientation and depth of the valley the transmission line is crossing, and on the span azimuths.

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GLOSSARY

Boundary layer - The layer of air adjacent to a surface which, when flowing, experiences the frictional and thermal effects of the surface.

Complex terrain - Rough and rugged surfaces of the earth with steep elevation changes; usually refers to mountainous terrain. Complex terrain contrasts to flat plains or gently rolling hills.

Coriolis force - An apparent force exerted on any object at or above the earth's surface due to the earth's rotation. 2 x earth's angular speed x sin (latitude) = Coriolis parameter.

Free stream - The layer of air flowing above a boundary layer which does not experience the surface friction effects. Free-stream speeds are used as reference speeds. In the atmosphere the free-stream wind is also called the gradient wind.

Gradient wind - Free-stream wind (described above) for the atmosphere.

Neutral atmosphere - The condition when the change in air temperature with elevation (lapse rate) is adiabatic. That is, there is no buoyant thermal energy in the air to cause an elevation change in any air parcel. A neutral atmosphere is contrasted with a stable or an unstable atmosphere.

Reynolds number (Re) - A nondimensional number which compares the scale of inertial forces to viscous forces. $Re = UL/\nu$, where U is wind speed, L is the characteristic length and ν is the fluid kinematic viscosity.

Rossby number - A nondimensional number which compares the scale of the wind to the Coriolis parameter times a reference height.

Shear layer - A boundary layer or any other layer which has a change in direction or speed.

Stationary - As in stationary turbulence: stationary measurements are repeatable at any given location (the properties of the turbulence do not change with time). An example would be the measurement of turbulence downwind of a fixed object under similar approach wind conditions. The results of such a measurement could produce wind statistics which would be equal after a long enough measurement time.

Strong wind - Wind in which mechanical mixing due to turbulence is sufficient to effectively destroy thermal effects within the boundary layer. Wind speeds exceeding 10 meters per second (22.4 mph) at a height of 10 m usually satisfy this requirement.

Velocity profile - A representation of the change in wind speed with change in elevation.

FIGURES

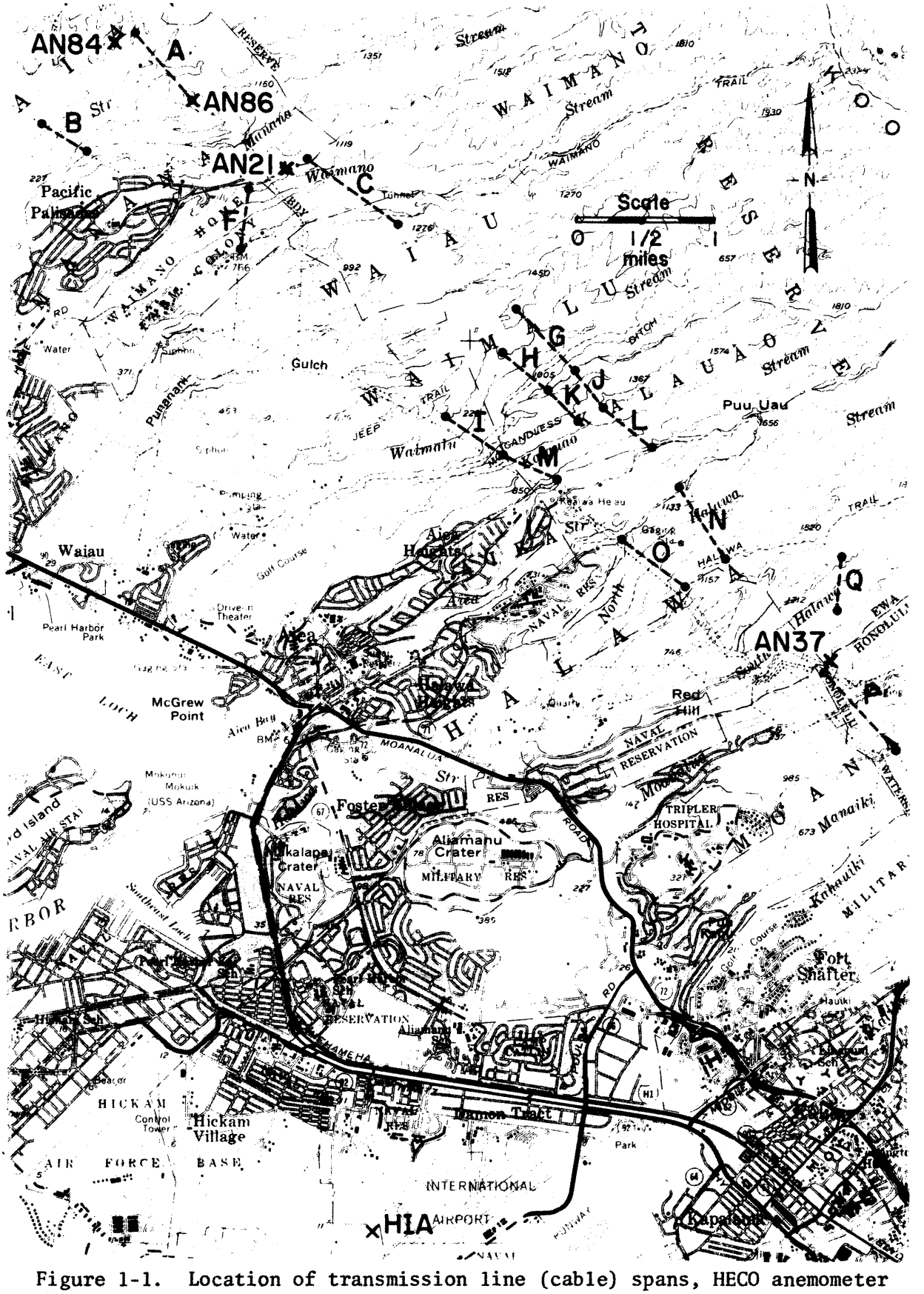


Figure 1-1. Location of transmission line (cable) spans, HECO anemometer sites and Honolulu International Airport (HIA).

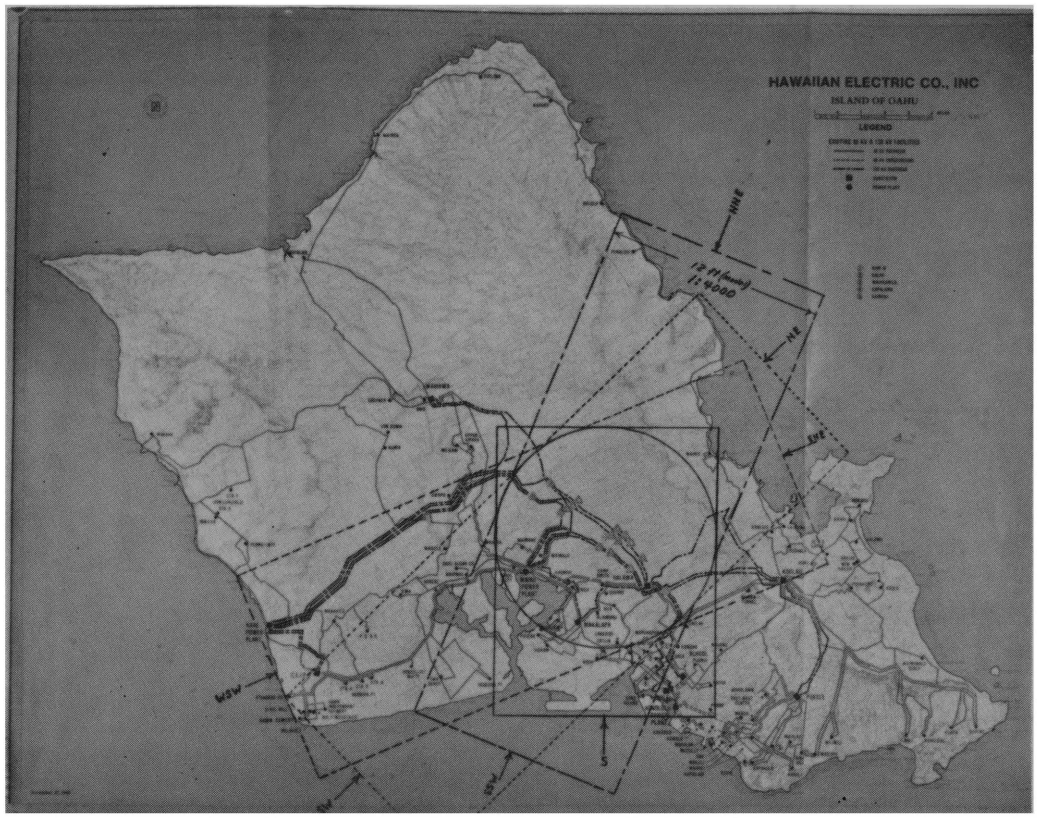


Figure 1-2. Map of model boundaries for S, SSW, SW, WSW, NNE and ENE wind directions.

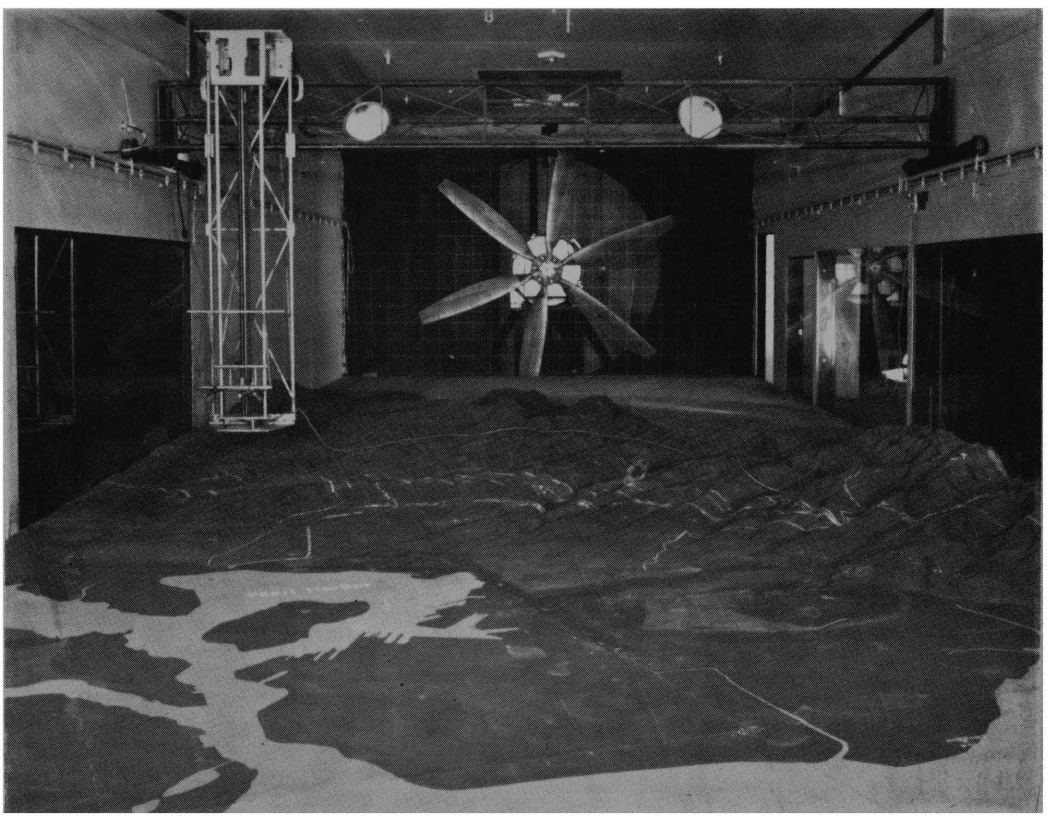


Figure 2-1. Oahu model for south southwest (SSW) wind direction.

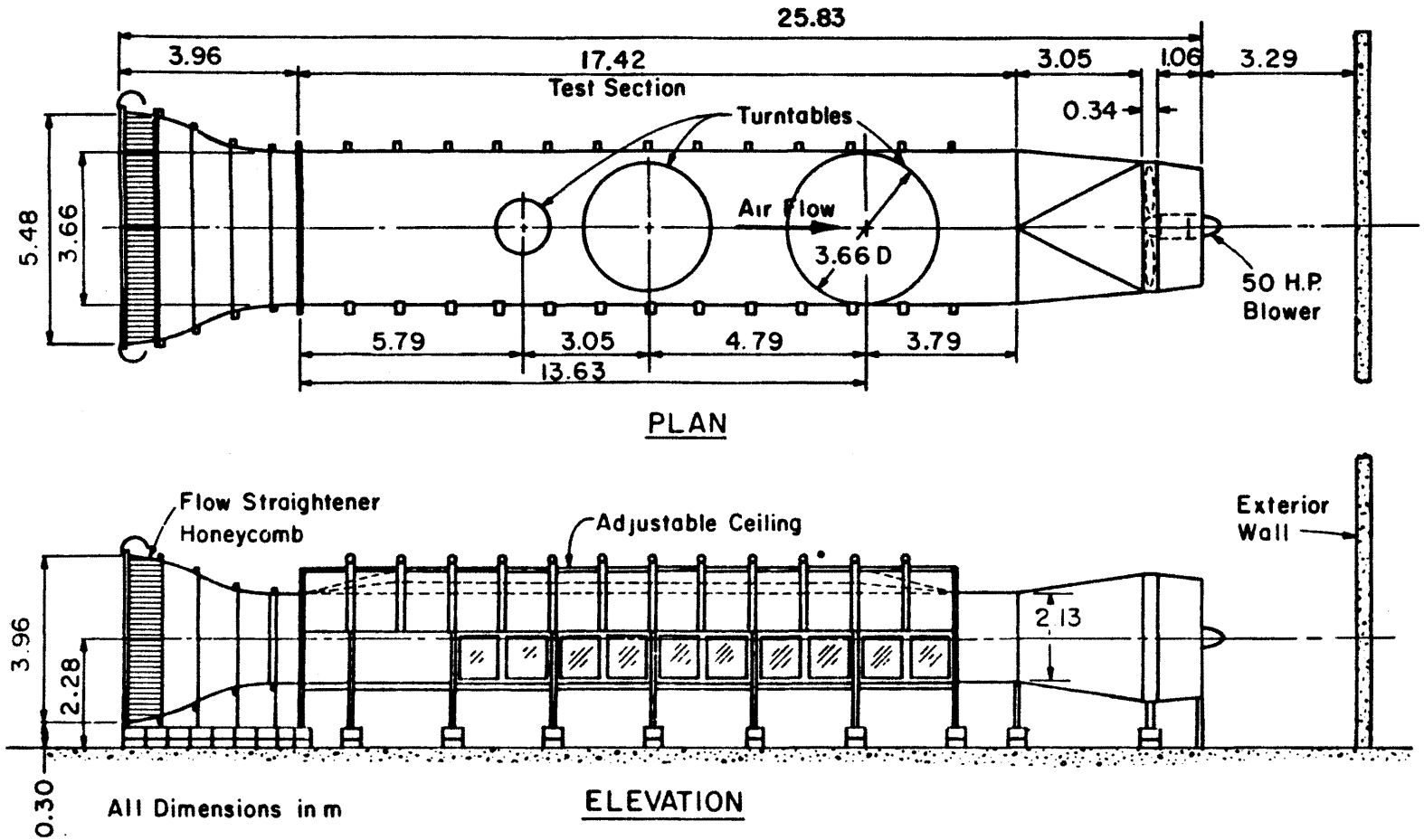


Figure 2-2. Environmental Wind Tunnel, Fluid Dynamics & Diffusion Laboratory, Colorado State University.

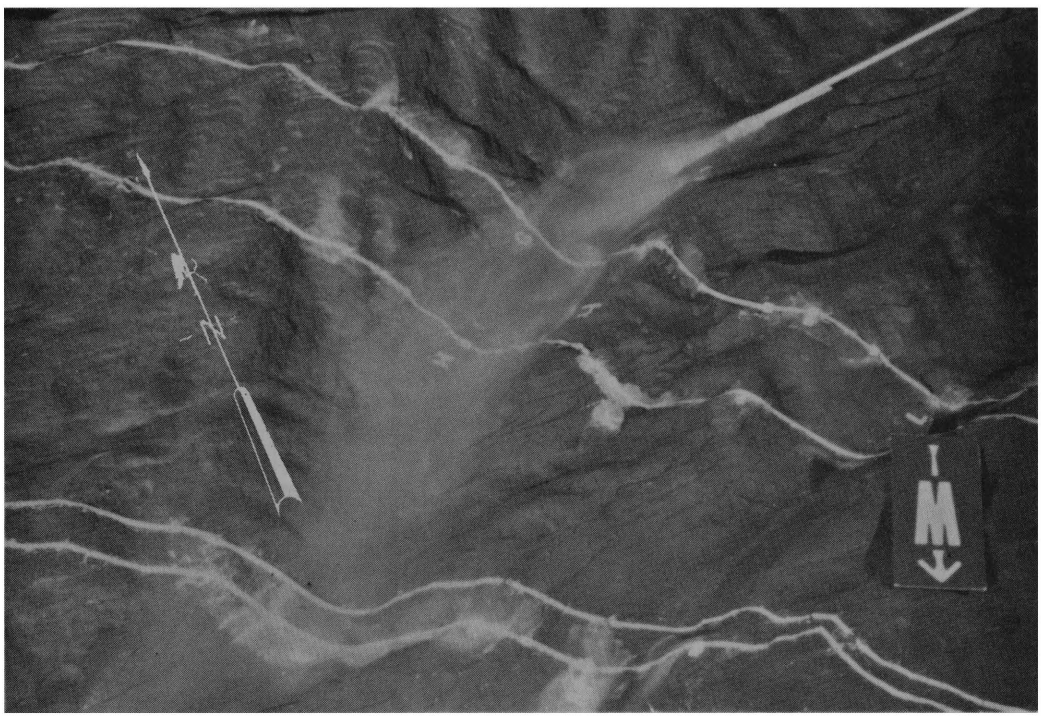


Figure 2-3. Wind flow for Spans G and H for the north northeast (NNE) wind direction. (The mean wind direction is indicated by the upside-down "W" arrow.)

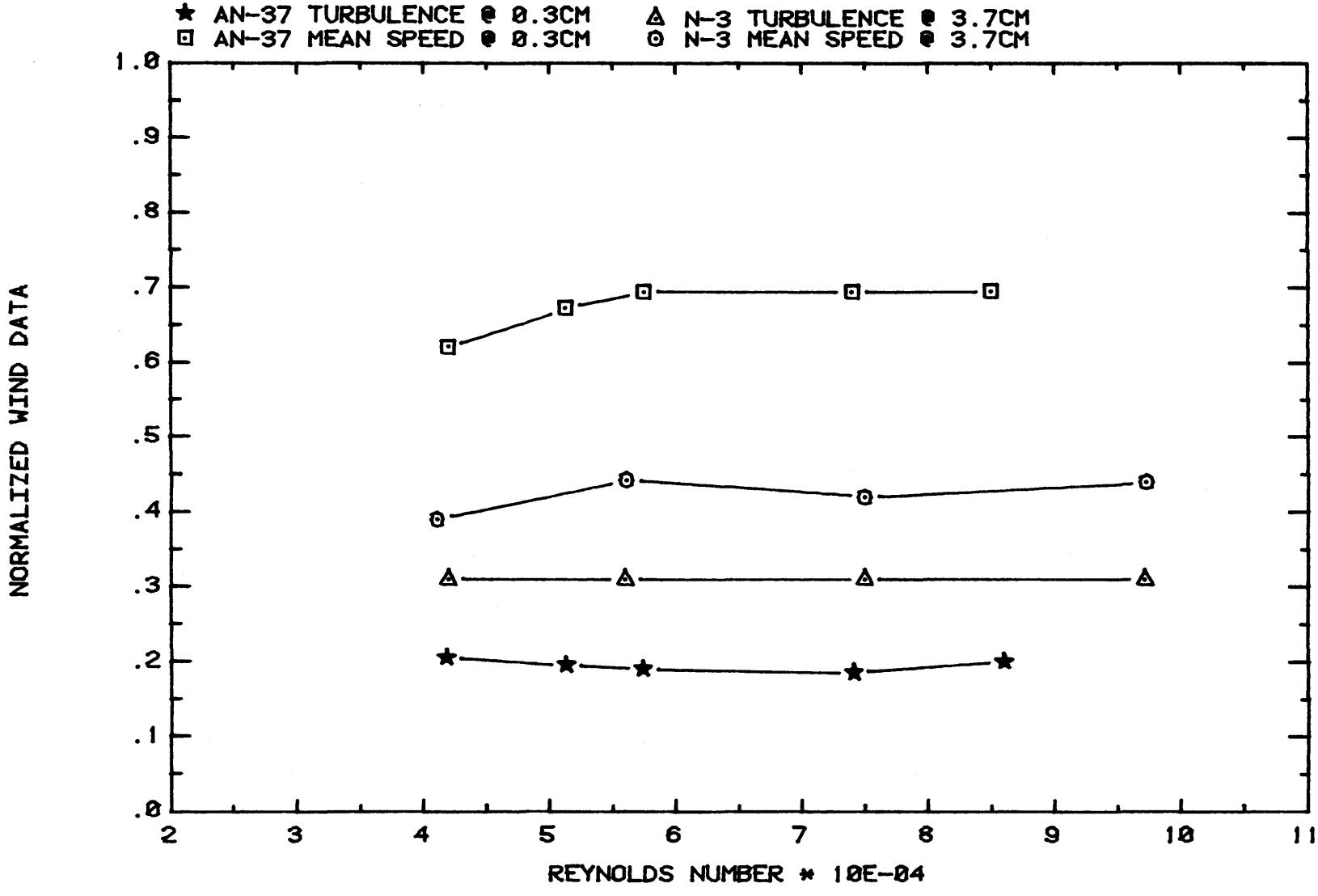


Figure 3-1. Reynolds number independence check.

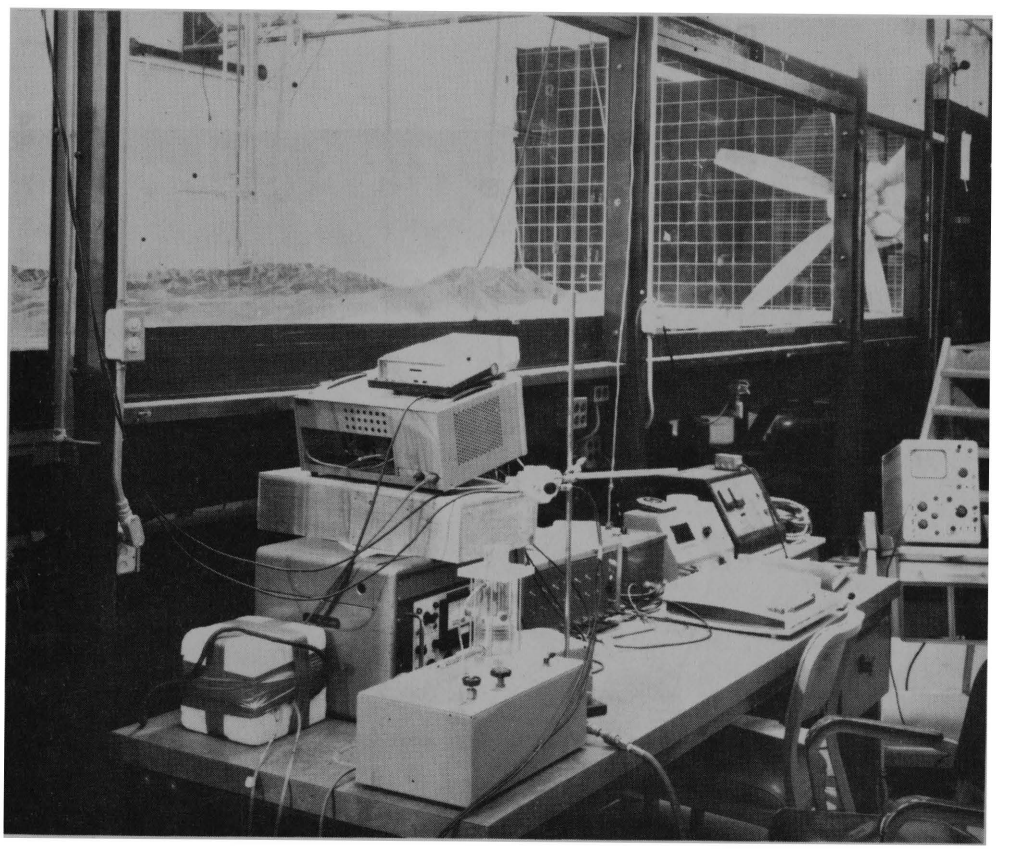


Figure 3-2. Photograph of experimental instrumentation with southwest (SW) model in wind-tunnel background.

TABLES

Table 2.1. Identification of Valley Crossings and Span Names

Valley	No. of Crossings	Span Names
Waiawa	2	A, B
Waimano	2	C, F
Waimalu	5	G, H, I, J, K
Kalauao	2	L, M
North Halawa	2	N, O
Moanalua	1	P
South Halawa	1	Q

Table 2.2. Hawaiian Electric Company Span and Location Information

Location[1]	Span Azimuth	Prototype Terrain Height (ft-msl)	Prototype Line Height (ft-msl)	Prototype Ground to Line (ft-agl)	Model Ground to Line (cm)	Data[2] Code Name
A1	139° 02'	855	940	85	0.65	AD11E
A2		440	756	316	2.40	AD12E
A3		400	718	318	2.42	AD13E
A4		480	768	288	2.19	AD14E
A5 (AN86)		880	955	75	0.57	AD15E
B1	121° 53.5'	635	695	60	0.46	BD16E
B2		315	620	305	2.32	BD17E
B3		260	610	350	2.67	BD18E
B4		380	635	255	1.94	BD19E
B5		660	725	65	0.50	BD20E
C1	314° 31.7'	1040	1075	35	0.27	CD21E
C2		540	938	398	3.03	CD22E
C3		520	865	345	2.63	CD23E
C4		720	949	229	1.74	CD24E
C5		1070	1105	35	0.27	CD25E
F1	189° 34.5'	945	1030	85	0.65	FD26E
F2		460	813	353	2.69	FD27E
F3		380	740	360	2.74	FD28E
F4		520	752	232	1.77	FD29E
F5		800	875	75	0.57	FD30E
G1	320° 49.5'	1320	1355	35	0.27	GD31E
G2		880	1048	168	1.28	GD32E
G3		560	914	354	2.70	GD33E
G4		480	932	452	3.44	GD34E
G5 (J1)		1090	1125	35	0.27	GD35E
H1	135° 12.3'	1070	1105	35	0.27	HD36E
H2		780	1035	255	1.94	HD37E
H3		360	950	590	4.50	HD38E
H4		480	962	482	3.67	HD39E
H5 (K1)		935	970	35	0.27	HD40E
I1	298° 32'	680	730	35	0.27	ID41E
I2		300	658	358	2.72	ID42E
I3		200	672	472	3.60	ID43E
I4		560	766	206	1.57	ID44E
I5 (M1)		880	940	60	0.46	ID45E
J2	320° 49.5'	760	1083	323	2.46	JD46E
J3		800	1090	290	2.21	JD47E
J4		1000	1140	140	1.07	JD48E
J5 (L1)		1200	1235	35	0.27	JD49E

Table 2.2 (continued).

Location[1]	Span Azimuth	Prototype Terrain Height (ft-msl)	Prototype Line Height (ft-msl)	Prototype Ground to Line (ft-agl)	Model Ground to Line (cm)	Data[2] Code Name
K2	135° 12.3'	680	940	260	1.98	KD50E
K3		540	950	410	3.12	KD51E
K4		760	997	237	1.81	KD52E
K5		1050	1085	35	0.27	KD53E
L2	309° 17.25'	930	1126	196	1.49	LD54E
L3		600	1099	499	3.80	LD55E
L4		900	1156	256	1.95	LD56E
L5		1260	1295	35	0.27	LD57E
M2	305° 35'	680	855	175	1.33	MD58E
M3		440	818	378	2.88	MD59E
M4		700	819	119	0.91	MD60E
M5		824	869	45	0.34	MD61E
N1	329° 0.75'	1140	1175	35	0.27	ND62E
N2		670	1010	340	2.59	ND63E
N3		370	955	585	4.46	ND64E
N4		795	1018	223	1.70	ND65E
N5		1160	1195	35	0.27	ND66E
O1	309° 11.5'	1015	1065	50	0.38	OD67E
O2		540	877	337	2.57	OD68E
O3		280	814	534	4.07	OD69E
O4		620	877	257	1.96	OD70E
O5		1005	1060	55	0.42	OD71E
P1	317° 04'	1123	1168	45	0.34	PD72E
P2		520	990	470	3.58	PD73E
P3		480	961	481	3.67	PD74E
P4		720	1075	355	2.71	PD75E
P5		1290	1340	50	0.38	PD76E
Q1	241° 30.75'	1407	1442	35	0.27	QD77E
Q2		1010	1174	164	1.25	QD78E
Q3		780	962	182	1.39	QD79E
Q4		580	790	210	1.60	QD80E
Q5		636	671	35	0.27	QD81E

Table 2.2 (continued).

Location[1]	Span Azimuth	Prototype Terrain Height (ft-msl)	Prototype Line Height (ft-msl)	Prototype Ground to Line (ft-agl)	Model Ground to Line (cm)	Data[2] Code Name
AN21						A921E
AN37						A937E
AN84						A984E
AN86						A986E
HIA						A911E
BPA/or Approach						A901E

[1]Location is either the point on a given span; i.e. B-2 is the 2nd point on Span B, a reference station or a HECO anemometer position. The following is a detailed description of Span A points:

A1 is the northernmost point on Span A
A2 is the first quarter point south of A1
A3 is the mid-span
A4 is the third quarter point south of A1
A5 is the south end of A

[2]D = Wind direction indicator
D=1 : SW
2 : WSW
3 : NNE
4 : ENE
5 : S
6 : SSW

[2]E = Elevation number (used when more than one data point is taken at the same location)

msl : mean sea level
agl : above ground level

Table 2.3. Hawaiian Electric Company Oahu Transmission Line Wind Study--Wind Data Sets (Number in table indicates number of elevations for which valid data were collected at each sampling location.)

Location	Wind Direction					
	S	SSW	SW	WSW	NNE	ENE
A1	4	5	2	4	2	2
A2	2	7	1	7		
A3	2	6	3	6	3	3
A4	2	6	1	6		
A5	3	3	10	3	3	
B1	5	4	2	4		
B2	1	1	1	1		
B3	1	2	1	1		
B4	1	1	1	1		
B5	4	4	2	4		
C1	4	3	2	3		
C2	1	1	1	1		
C3	1	1	1	1		
C4	1	2	1	1		
C5	4	3	2	3		
F1	4	4	2	4		
F2	1	1	1	1		
F3	1	1	1	1		
F4	1	1	1	1		
F5	5	4	2	4		
G1	4	3	2	3		
G2	8	1	1	1		
G3	1	1	1	1		
G4	1	1	1	1		
G5 (J1)	4	3	2	3		
H1	4	3	2	3		
H2	1	1	1	1		
H3	1	1	1	1		
H4	1	1	1	1		
H5 (K1)	4	3	2	3		
I1	4	2	2	3		
I2	1	1	1	1		
I3	1	1	1	1		
I4	1	1	1	1		
I5 (M1)	4	2	2	3		

Table 2.3 (continued).

Location	Wind Direction					
	S	SSW	SW	WSW	NNE	ENE
J2	1	1	1	1		
J3	1	1	1	1		
J4	4	1	1	1		
J5 (L1)	4	3	2	3		
K2	5	1	1	1		
K3	5	1	1	1	3	3
K4	5	1	1	1		
K5	4	3	3	3	2	2
L2	6	1	1	1		
L3	6	1	1	1		
L4	6	1	1	1		
L5	4	3	2	3		
M2	5	1	1	1		
M3	5	1	1	1		
M4	4	1	1	1		
M5	4	2	2	3		
N1	6	3	3	3	2	2
N2	5	5	5	5		
N3	5	5	5	5	3	3
N4	7	5	5	5		
N5	5	3	3	3		
O1	4	3	2	3		
O2	5	1	1	1		
O3	5	1	1	1		
O4	5	1	1	1		
O5	4	4	2	3		
P1	4	3	4	3	2	2
P2	6	6	1	5		
P3	6	5	5	5	3	3
P4	5	5	1	5		
P5	6	3	5	3		
Q1	4	3	2	3		
Q2	6	1	1	1		
Q3	6	1	1	1		
Q4	6	1	1	1		
Q5	5	3	2	3		

Table 2.3 (continued).

Location	Wind Direction S	SSW	SW	WSW	NNE	ENE
HECO Anemometer Locations						
AN21	10	10	10	10	10	18
AN37	10	10	10	10	10	9
AN84	10	10	10	11	10	18
AN86	10	10	10	10	10	18
Airport Anemometers						
HIA	10	9	9	*	10	*
BPA/Approach	10	*		10		10

Reynolds-number independence test was made for the S wind directions.

*Location Off Model

Table 3.1. Maximum Mean Horizontal Perpendicular Normalized Wind Speed (U MEAN) and Location (in parentheses) at Transmission-line Height by Wind Direction

Span	S	SSW	SW	WSW	NNE	ENE
A	0.57 (A2)	0.70 (A2-A3-A5)	0.76 (A4)	0.66 (A4)	0.54 (A5)	0.39 (A1)
B	0.65 (B5)	0.85 (B5)	0.75 (B5)	0.65 (B5)		
C	0.40 (C1)	0.60 (C3)	0.64 (C5-C2)	0.81 (C5)		
F	* *	* *	* *	0.61 (F3)		
G	* *	0.70 (G3)	0.80 (G3)	0.78 (G4)		
H	0.42 (H2)	0.65 (H3)	0.78 (H3-H4)	0.72 (H4)		
I	0.61 (I5)	0.69 (I2)	0.63 (I2)	0.69 (I2)		
J	* *	0.61 (J2)	0.77 (J5)	0.75 (J2)		
K	0.50 (K5)	0.53 (K2)	0.59 (K5)	0.68 (K2)	0.54 (K5)	0.50 (K3)
L	0.52 (L5)	0.57 (L2)	0.62 (L2)	0.64 (L3)		
M	0.52 (M5)	0.72 (M2)	0.75 (M3)	0.63 (M4)		
N	0.47 (N5)	0.58 (N3)	0.75 (N3)	0.81 (N3)	0.30 (N3)	0.58 (N3)
O	0.61 (O2)	0.71 (O2)	0.78 (O3)	0.64 (O4)		
P	* *	0.53 (P3)	0.80 (P2)	0.71 (P2)	0.24 (P3)	0.54 (P3)
Q	0.78 (Q1)	* *	* *	* *		

*Parallel component greater than perpendicular component.

Table 4.1. One-hour Mean Gradient Wind Speeds (mph) for Three Recurrence Intervals

	Recurrence 10 Years			Recurrence 50 Years			Recurrence 100 Years		
	Data Set			Data Set			Data Set		
Direction	1	2	3	1	2	3	1	2	3
N	47	42	31	58	54	34	62	60	35
NNE		45	49		54	53		57	55
NE	58	46	55	67	54	58	72	57	59
ENE		47	50		54	53		57	54
E	51	45	49	58	54	52	62	58	53
ESE		41	47		51	52		55	54
SE	55	48	60	68	61	66	74	67	68
SSE		42	47		53	51		58	52
S	47	47	44	57	60	48	61	66	49
SSW		56	62		77	69		86	72
SW	55	59	*	71	63	*	78	69	*
WSW		51	54		68	61		75	63
W	53	52	40	66	67	45	72	74	47
WNW		48	26		63	28		69	29
NW	45	46	25	54	61	27	58	67	27
NNW		38	28		54	30		61	31

Data Set 1 = HIA Fastest Mile Winds
Data Set 2 = BPA Gust Winds
Data Set 3 = HIA Hourly Winds

*Insufficient data to provide adequate fit to distribution.

APPENDICES

APPENDIX A

MODEL CONSTRUCTION

APPENDIX A

MODEL CONSTRUCTION

Typically, terrain models are constructed by laminating contoured plates at chosen thickness--usually dictated by available contour maps--on top of each other. For this project, however, a terrain "model carving" jig was employed. The jig consists of a vertically adjustable electric router mounted on an XY-coordinate rail system. Each 40-ft contour was projected onto a 4-in.-thick piece of ethafoam. The ethafoam was then routed one contour level at a time from the sea level to the highest level for that particular piece of ethafoam. The router bit cutting traverse along contour lines was done manually. This method proved to be more accurate than the lamination method since there is no error due to plate orientation of contour layers nor due to glueing of numerous contour plates. Also, the model is lightweight, which allowed for easier handling. Since the time required to manually plot and route each contour line was substantial, contour maps of the more complicated terrain were photographed, enlarged to scale on nonshrink photographic paper and glued to the top of the ethafoam surfaces. Figure A-1 shows the model construction set up with the router jig in top right center. After the ethafoam was routed it was smoothed, employing a combination of sanding and surface heating (partial melting) with a hot air gun. The ethafoam employed had 1/32-in. to 1/16-in. voids which, after smoothing and painting, gave roughness elements on the order of 15 ft. According to Neal (1983) it is very important to eliminate the contour steps resulting from model construction.

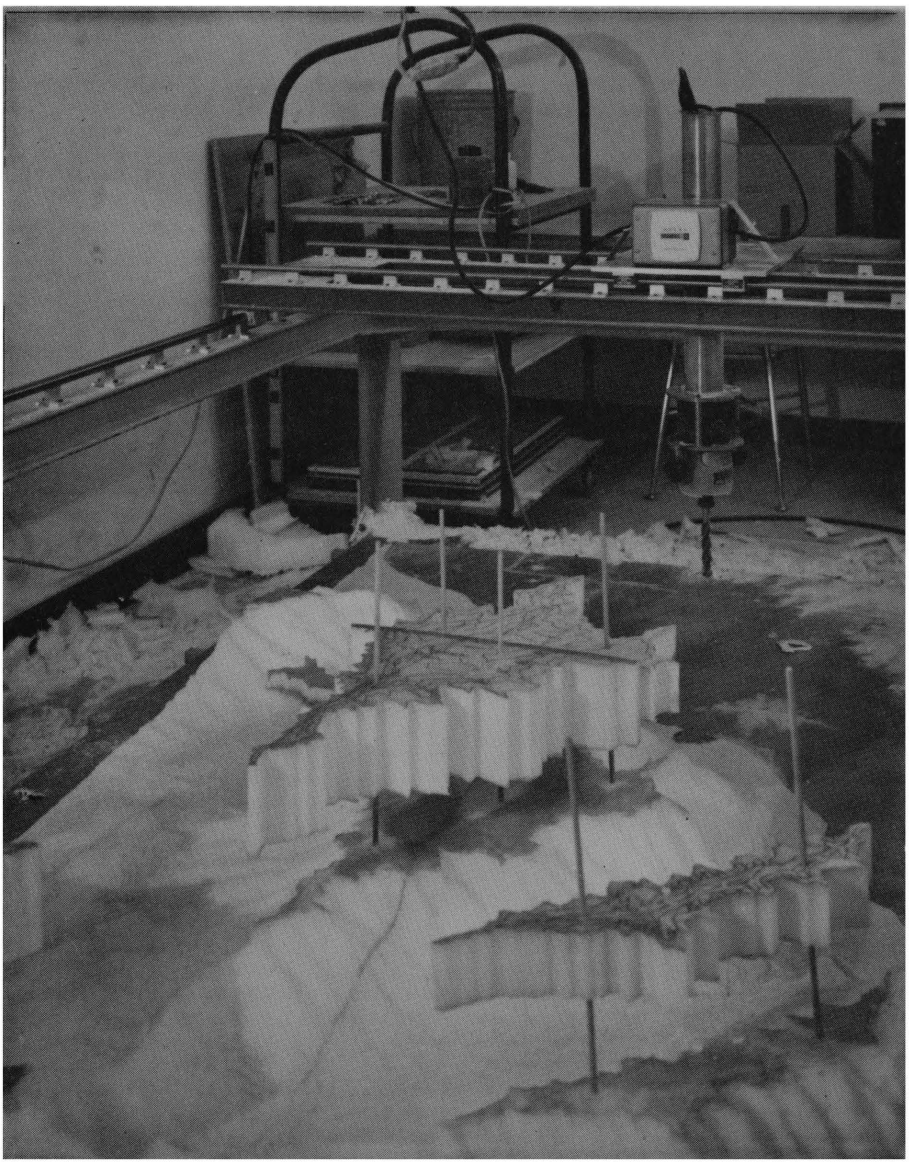


Figure A-1. Model construction setup with router jig.

APPENDIX B

HOT-FILM ANEMOMETRY

APPENDIX B

HOT-FILM ANEMOMETRY

Two X-film anemometer probes were employed in the present study. A standard X-probe (Fig. B-1), TSI Model 1241-20, for cross-flow measurement was used to measure velocity components in the horizontal X-Y plane. A boundary-layer X-probe, TSI Model 1243-20, for cross-flow measurement was used to measure velocity components in the vertical X-Z plane. The Model 1241-20 X-probe features two hot-film sensing elements oriented 90° to each other and 90° to the probe axis. The two sensing elements are mounted on two closely spaced vertical planes, 0.04 in. in separation, parallel to the probe axis. The boundary-layer X-probe features two hot-film sensors 90° to each other and 45° to probe axis while the two sensing elements are mounted on two closely spaced planes, 0.04 in. in separation, parallel to probe axis. Each platinum hot-film sensor is 0.002 in. in diameter and 0.065 in. long.

Two TSI Model 1053B constant-temperature hot-wire anemometers were utilized in conjunction with the X-probes. These anemometers are essentially the black box that converts the air flow sensed by the X-probe into a voltage representative of the wind speed. Outputs from these anemometers were sent to an HP-1000 mini-computer for on-line analysis. Each X-probe was calibrated prior to the wind-tunnel data collection, using a TSI Model 1125 calibrator and an MKS Type 77H-30 Baratron pressure meter. Typical calibration curves are shown in Fig. B-2. Since the X-probe was properly positioned at each measurement location with both sensing elements 45° to the local mean flow, calibration was performed with the same configuration so that any interference between the sensing elements was the same during calibration and data

collection. Calibration data were fitted to a variable exponent form of King's Law,

$$E_i^2 = A_i + B_i U_{Ni}^{n_i} , \tag{B-1}$$

where E_i is the hot-film output voltage, U_{Ni} is the approaching mean velocity, and A_i, B_i, and n_i are calibration constants for sensing element i.

The velocity components U and V are then read as

$$U = \frac{1}{2} (U_{N1} + U_{N2})$$

$$V = \frac{1}{2} (U_{N1} - U_{N2}) \tag{B-2}$$

Equation (B-2) can be obtained from the classical operating principle of a yawed wire, as discussed by Sandborn (1972), in conjunction with the above described calibration technique. For further information refer to Bradshaw (1971), Comte-Bellot (1977), Sandborn and Slogar (1955), and Bienkiewicz (1981) for the operating principle of X-film probe measurements.

The X-probes are primarily designed for two-dimensional turbulence measurements. For three-dimensional turbulence measurements, a complete set of data for each selected location is then composed of u-v measurements and u-w measurements using the standard UV X-probe and the boundary-layer UW X-probe, respectively. Angular sensitivity of the standard X-probe is presented in Fig. B-3 where the true mean flow direction was observed from the balancing between the two sensing element anemometers output. Figure B-3 also shows that the mean velocity measurement is within 1 percent error for a wind angle measured within ±7° of the mean flow direction. The technique of locating the local mean flow direction by balancing two anemometer outputs was

employed in conjunction with flow visualization to yield the true local mean flow direction. The UW X-probe is rather insensitive to an attack angle with respect to the measuring plane. Figure B-4 shows that only 1 percent of error resulted from the misalignment of the boundary-layer X-probe by ±10°.

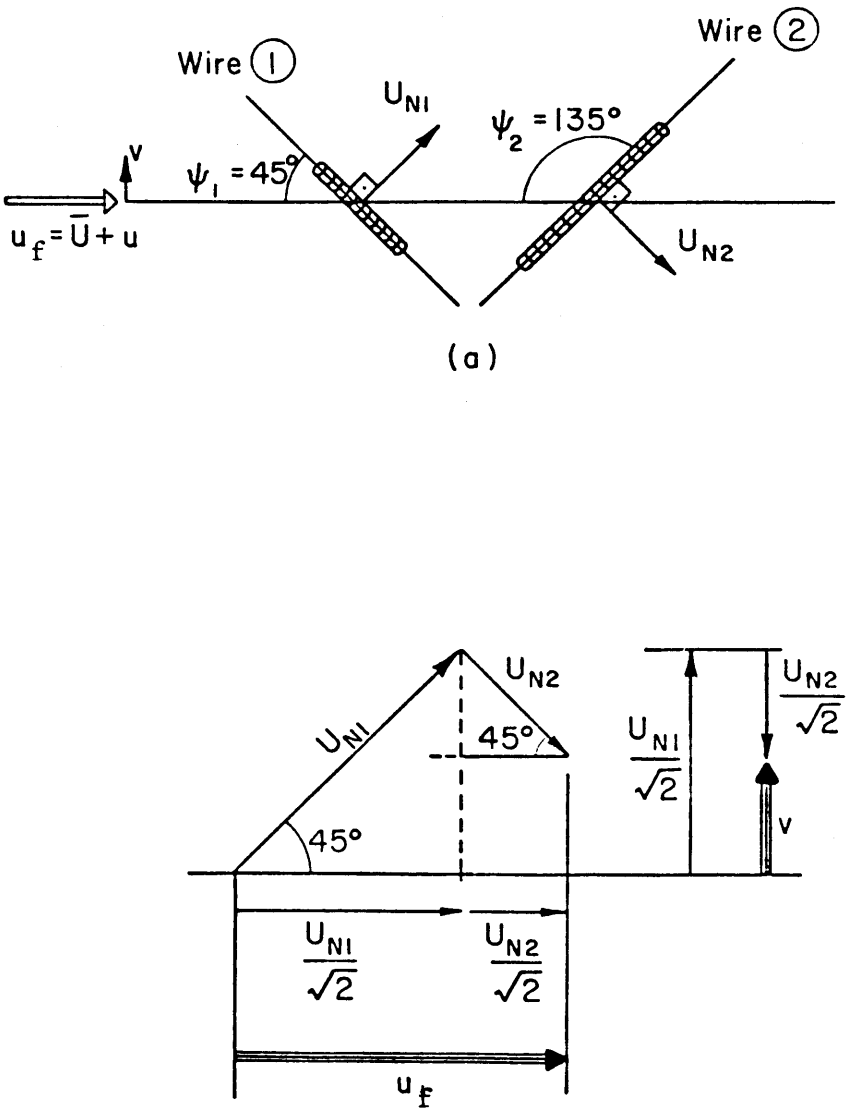


Figure B-1. Film orientation for standard X-film probe (u_f is the total measured mean plus turbulent wind speed).

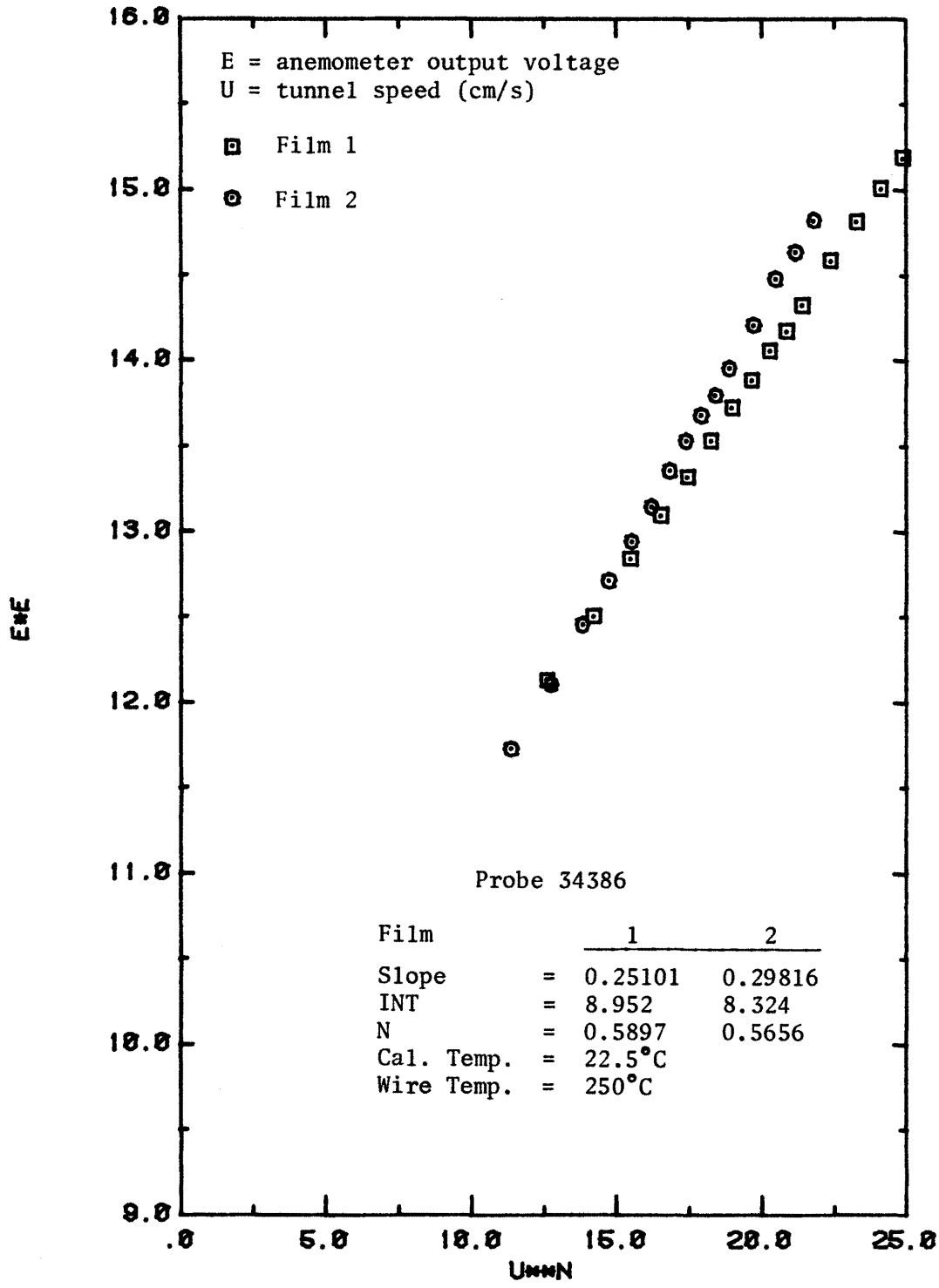


Figure B-2. Typical calibration curves for hot-film anemometer.

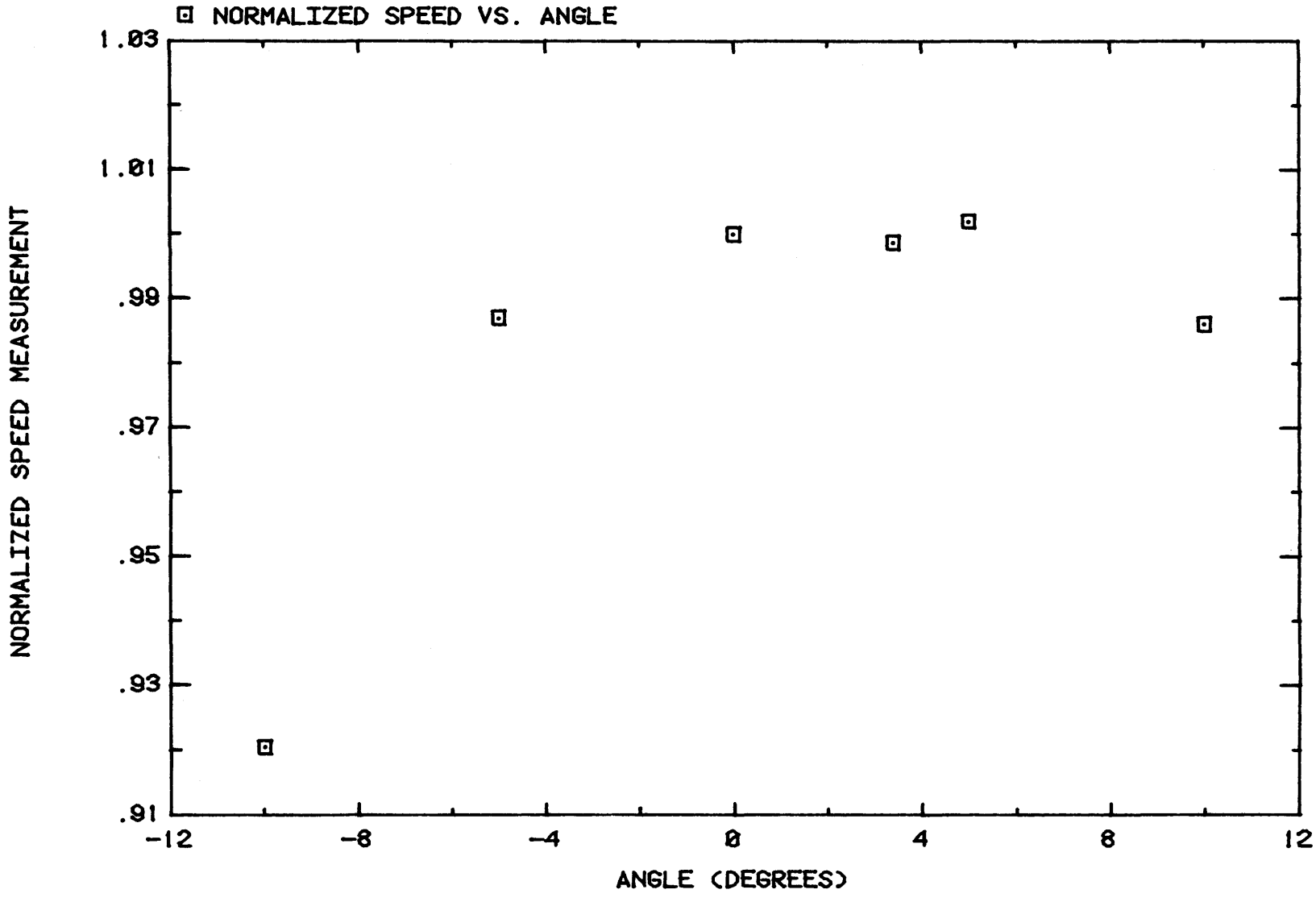


Figure B-3. Angular sensitivity of the standard X-film probe.

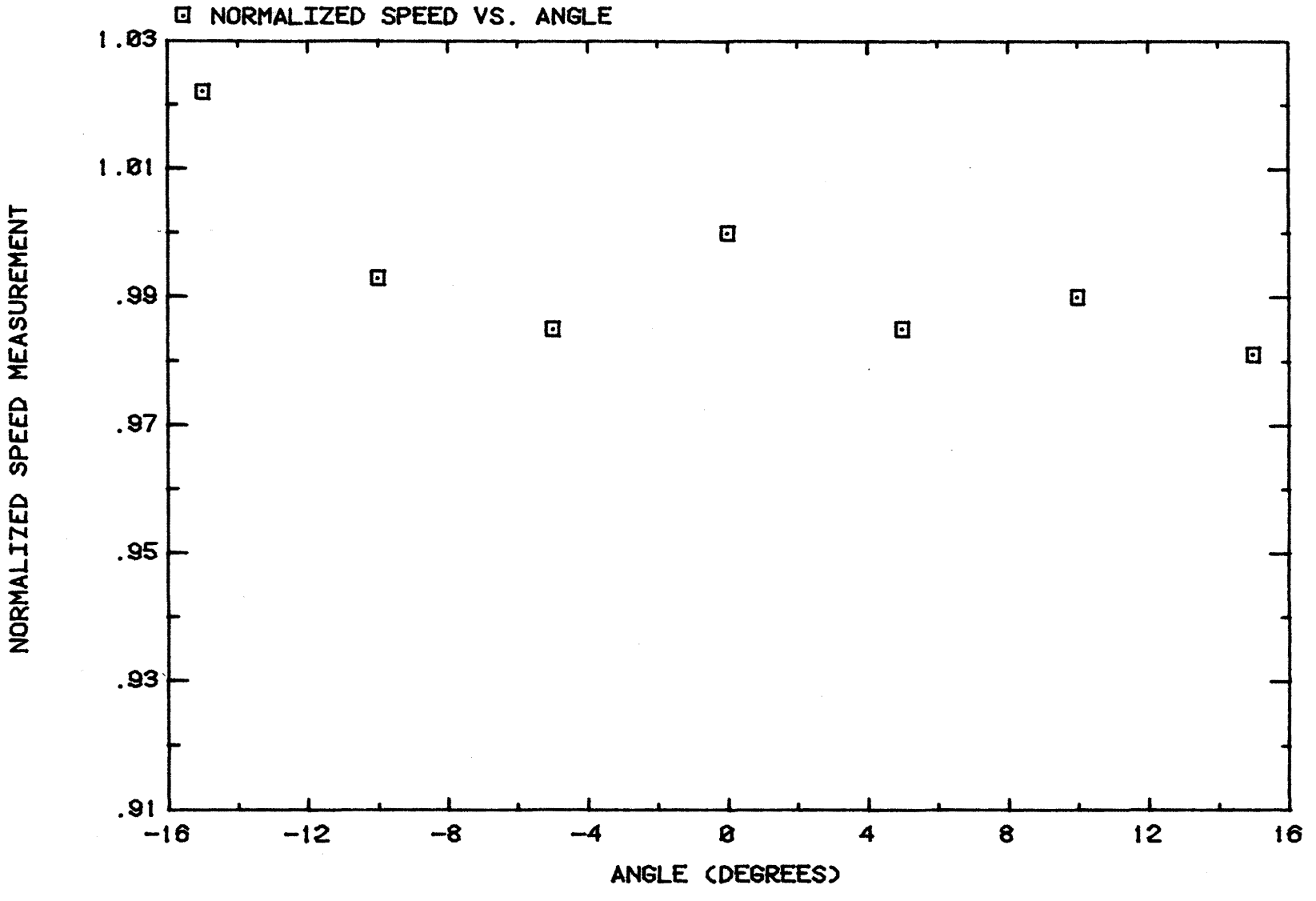


Figure B-4. Angular sensitivity of the boundary layer X-film probe

APPENDIX C

COORDINATE SYSTEMS AND TRANSFORMATIONS

APPENDIX C

COORDINATE SYSTEMS AND TRANSFORMATIONS

Several coordinate transformations were required for data reduction in this study. The data is presented in local rectangular coordinates for the transmission line data and in geographical coordinates or National Weather Service format for the anemometer data.

1.0 Reference mean velocity $\bar{U}_{ref}$:

This quantity, used to scale local mean velocity components ($\bar{U}$, $\bar{V}$, $\bar{W}$) and root-mean-square (rms) turbulence components [$(\overline{u^2})^{\frac{1}{2}}$, $(\overline{v^2})^{\frac{1}{2}}$, $(\overline{w^2})^{\frac{1}{2}}$], is measured above the wind-tunnel boundary layer in flow approaching the island as shown in Fig. C-1. $\bar{U}_{ref}$ is the free-stream velocity.

2.0 Conversion for scaling by mean velocity at airport $\bar{U}_{HIA}$ or $\bar{U}_{BPA}$:

In order to relate local mean velocity and rms turbulence data measured in the wind tunnel for strong wind conditions to mean wind velocities measured in the field, these data can be scaled with mean wind velocity measured by an anemometer at the Honolulu International Airport $\bar{U}_{HIA}$ or at Barbers Point Naval Air Station $\bar{U}_{BPA}$ (see Fig. C-1). Measurements of $\bar{U}_{ref}$, $\bar{U}_{HIA}$ or $\bar{U}_{BPA}$ were obtained in the wind tunnel for each wind direction studied. Therefore, the ratio $\bar{U}_{ref}/\bar{U}_{HIA}$ or $\bar{U}_{ref}/\bar{U}_{BPA}$ is determined by the physical model. Conversion of velocity data scaled with $\bar{U}_{ref}$ to data scaled with $\bar{U}_{HIA}$ or $\bar{U}_{BPA}$ is accomplished by multiplication with the appropriate ratio of reference velocities as follows (using the local mean velocity $\bar{U}$, for example):

$$\bar{U}/\bar{U}_{HIA} = (\bar{U}/\bar{U}_{ref})(\bar{U}_{ref}/\bar{U}_{HIA})$$

or $$\bar{U}/\bar{U}_{BPA} = (\bar{U}/\bar{U}_{ref})(\bar{U}_{ref}/\bar{U}_{BPA})$$

The typical $\bar{U}_{ref}/\bar{U}_{HIA}$ and $\bar{U}_{ref}/\bar{U}_{BPA}$ conversion ratios for this study were similar and fairly constant: 2.0 for S, SSW, SW and WSW winds; and 1.6 for ENE and NNE winds.

3.0 Reference coordinate systems:

Two rectangular coordinate systems (x, y, z) are used to specify wind velocity and rms turbulence components. In both systems, the transmission line system and the geographical system, the z-coordinate is the vertical component (positive upward) and the x,y-coordinates are in a horizontal plane.

3.1 Transmission line system--This system is used to specify wind components measured at points along the various transmission line spans. As shown in Fig. C-2(a), x is perpendicular to the transmission line and y is parallel to the line. The y-component is typically positive in the northerly direction for the S, SSW, SW and WSW directions.

3.2 Geographical (National Weather Service) system--This system is used to specify winds measured at anemometer locations - the HIA and BPA airports and HECO anemometers. In order to facilitate use of full-scale airport data given by the National Weather Service, the x- and y-components are combined to give the resultant and taken positive in the mean wind direction. The w-component is positive in the upward direction. This system is shown in Fig. C-2(b).

4.0 Transformation of Coordinates:

In order to specify wind velocity and rms turbulence component acting on the transmission line, wind characteristics are transformed from the as-measured local coordinate system to the desired reference coordinate system determined by the transmission line azimuth.

Consider coordinate systems XYZ and X'Y'Z', as shown in Fig. C-3, the unit velocity vectors in both coordinates may be related to each other as follows:

$$\begin{bmatrix} U' \\ V' \\ W' \end{bmatrix} = \begin{bmatrix} \cos\phi\cos\theta & -\cos\phi\sin\theta & \sin\phi \\ \sin\theta & \cos\theta & 0 \\ -\sin\theta\cos\theta & \sin\phi\sin\theta & \cos\phi \end{bmatrix} \begin{bmatrix} U \\ V \\ W \end{bmatrix}$$

Notice that the coordinate system is rotated in a clockwise direction from XY to X'Y' about Z and then from XZ to X'Z' about Y'. A reverse relationship is obtained through matrix manipulation as follows:

$$\begin{bmatrix} U \\ V \\ W \end{bmatrix} = \begin{bmatrix} \cos\theta\cos\phi & \sin\theta & -\cos\theta\sin\phi \\ -\sin\theta\cos\phi & \cos\theta & \sin\theta\sin\phi \\ \sin\phi & 0 & \cos\phi \end{bmatrix} \begin{bmatrix} U' \\ V' \\ W' \end{bmatrix}$$

If the velocity components are decomposed as mean and fluctuating part such as

$$U = \bar{U} + u \ ,$$

$$V = \bar{V} + v \ , \quad \text{and}$$

$$W = \bar{W} + w$$

the following relationships are obtained through Reynolds analogy:

$$\bar{U}' = \cos\theta\cos\phi\ \bar{U} - \sin\theta\cos\phi\ \bar{V} + \sin\phi\ \bar{W} \ .$$

$$\bar{V}' = \sin\theta\ \bar{U} + \cos\theta\ \bar{V} \ .$$

$$\bar{W}' = -\cos\theta\sin\phi\ \bar{U} + \sin\theta\sin\phi\ \bar{V} + \cos\phi\ \bar{W} \ .$$

$$\overline{u'^2} = \cos^2\theta\cos^2\phi\ \overline{u^2} + \sin^2\theta\cos^2\phi\ \overline{v^2} + \sin^2\phi\ \overline{w^2} - 2\cos\theta\sin\theta\cos^2\phi\ \overline{uv} - 2\sin\theta\sin\phi\cos\phi\ \overline{vw} + 2\cos\theta\cos\phi\sin\phi\ \overline{uw} \ .$$

$$\overline{v'^2} = \sin^2\theta\ \overline{u^2} + \cos^2\theta\ \overline{v^2} + 2\sin\theta\cos\theta\ \overline{uv} \ .$$

$$\overline{w'^2} = \cos^2\theta\sin^2\phi\ \overline{u^2} + \sin^2\theta\sin^2\phi\ \overline{v^2} + \cos^2\phi\ \overline{w^2} - 2\sin^2\phi\cos\theta\sin\theta\ \overline{uv} - 2\cos\theta\sin\phi\cos\phi\ \overline{uw} + 2\sin\theta\sin\phi\cos\phi\ \overline{vw} \ .$$

The standard X-probe measurement provides information for U, V, u^2, v^2 and $\overline{uv}$ while the boundary-layer X-probe measurement provides information for U, W, $\overline{u^2}$, $\overline{w^2}$ and $\overline{uw}$. The $\overline{vw}$ term is generally negligible in comparison with other shear stress terms in a turbulent boundary-layer flow as demonstrated in Marsh (1977). In the present study, $\phi = 0$ was used for all measurements so that the $\overline{vw}$ term is not important in the transformation.

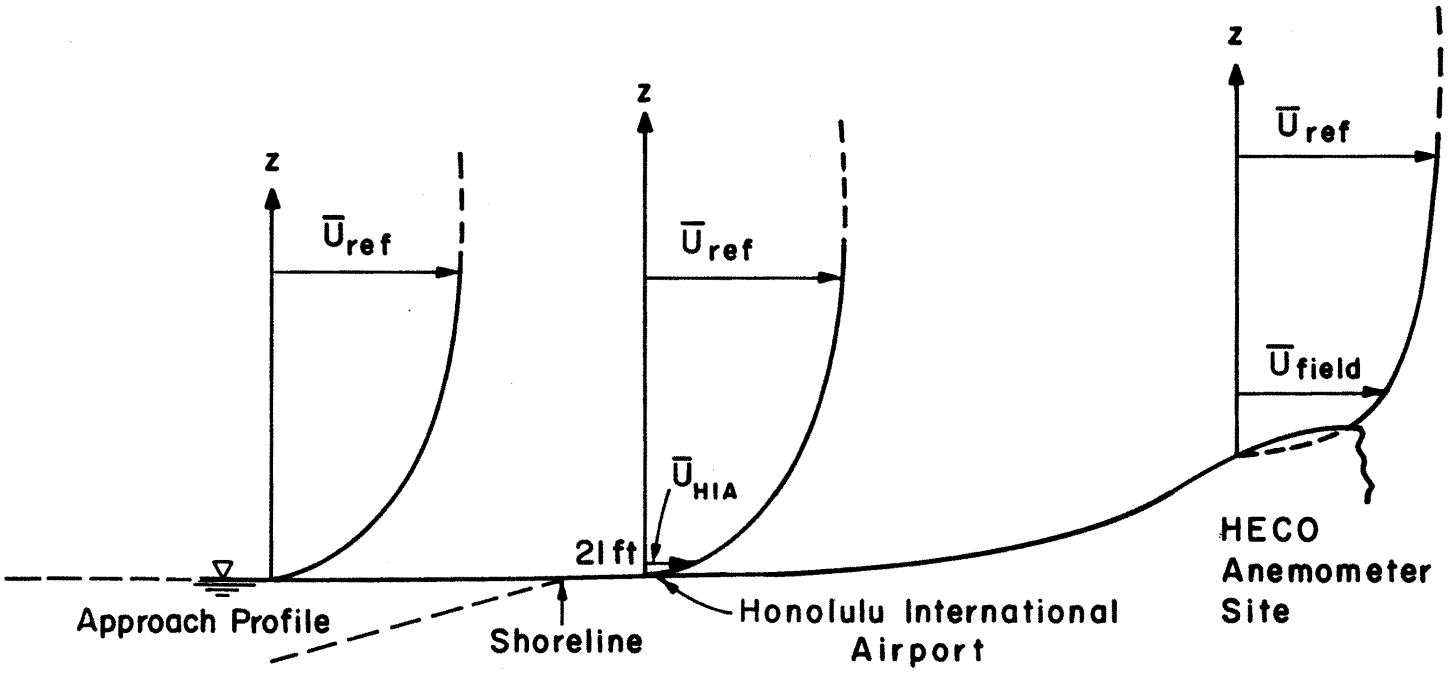
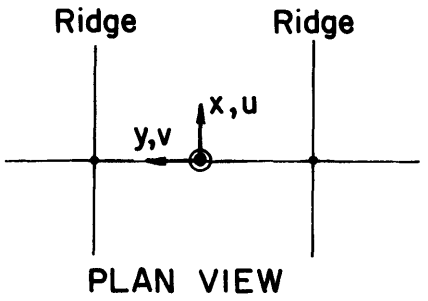
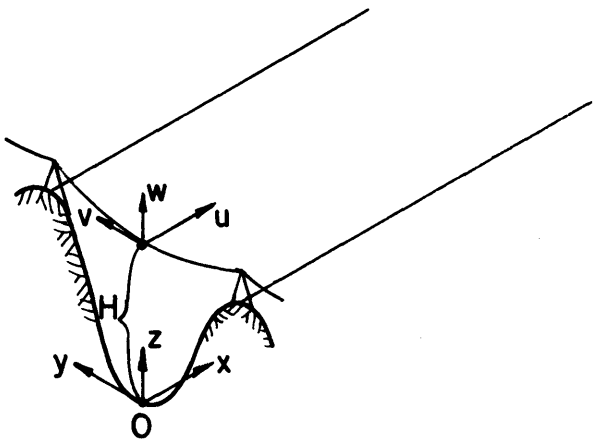


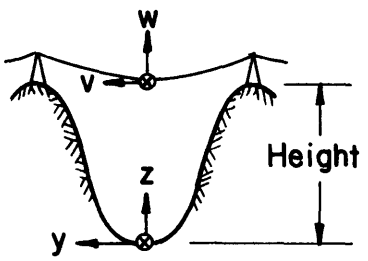
Figure C-1. Definition of reference wind speeds.



PLAN VIEW

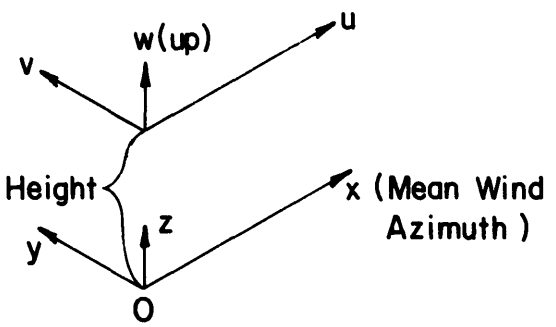


ISOMETRIC
(Origin at Ground Level)



FRONT VIEW

a) Transmission Line System



(Origin at Ground Level)

b) Geographical System

Figure C-2. Definition of coordinate systems.

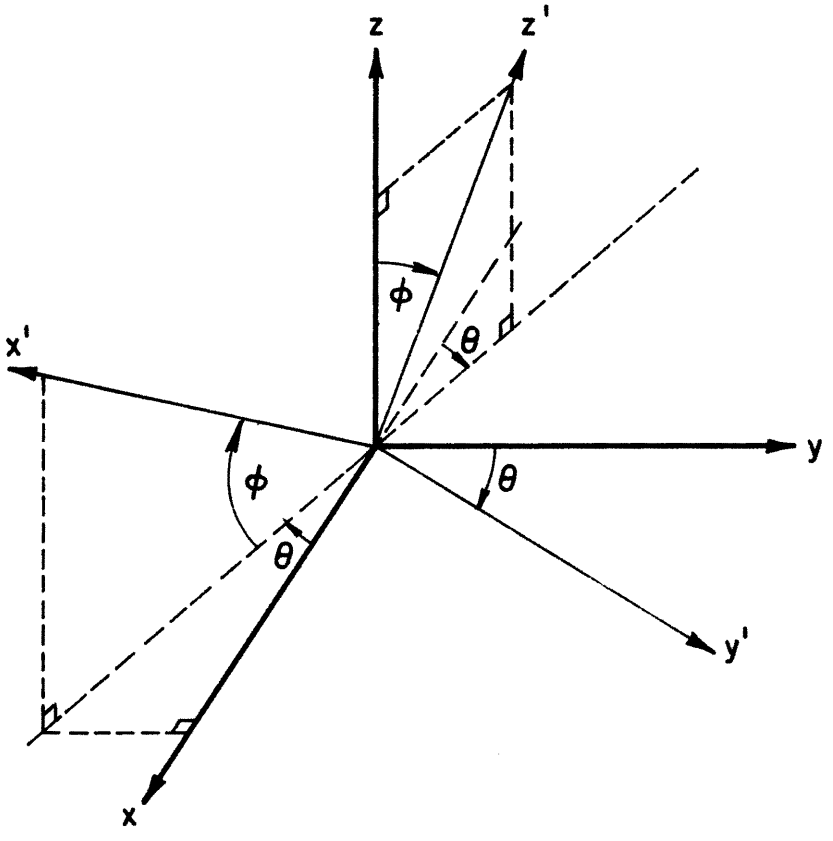


Figure C-3. Coordinate rotation diagram.

APPENDIX D

VELOCITY PROFILES AT ANEMOMETER LOCATIONS

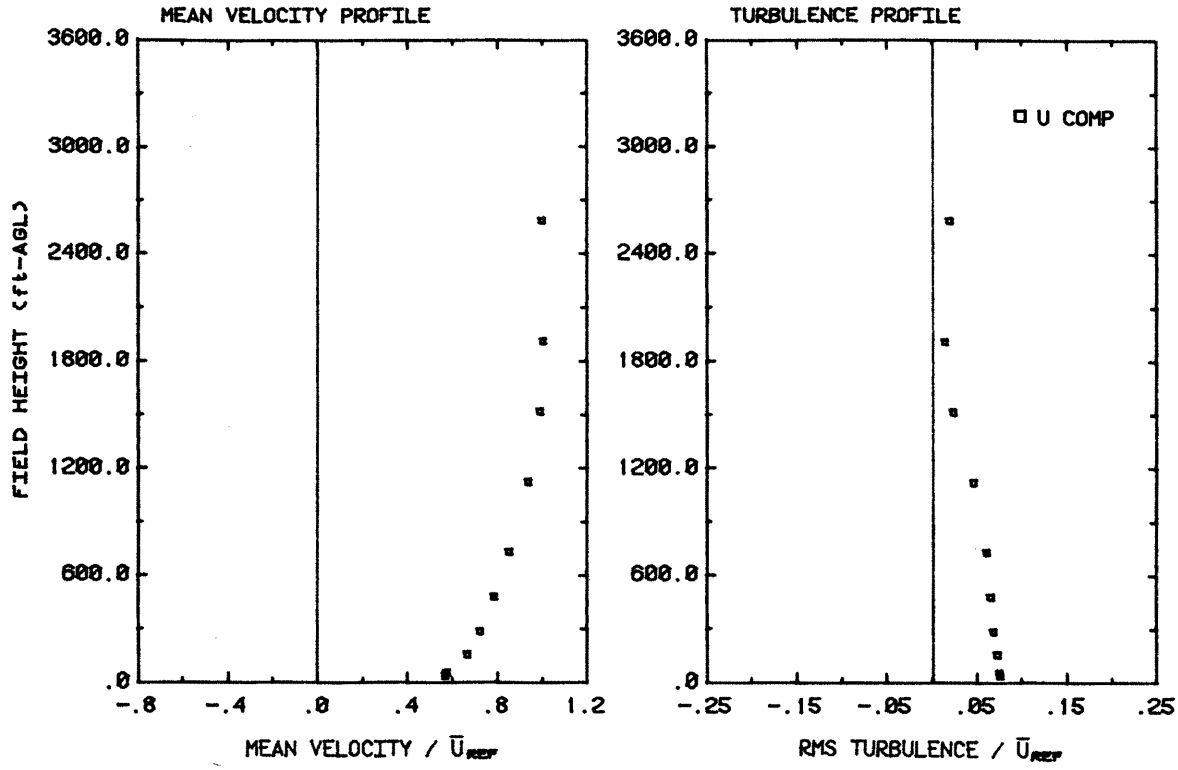


Figure D-1. Normalized mean velocities and turbulence intensity for approach flow for the south (S) wind direction.

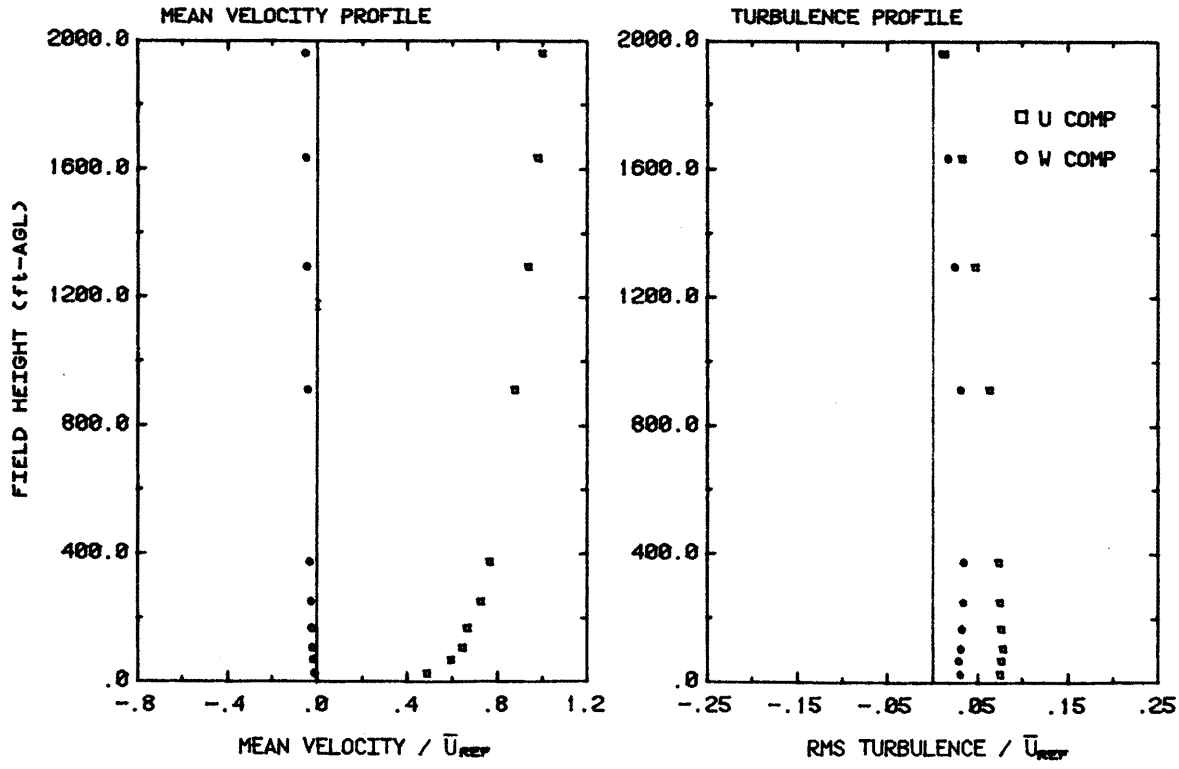


Figure D-2. Normalized mean velocities and turbulence intensity for HIA for the south (S) wind direction.

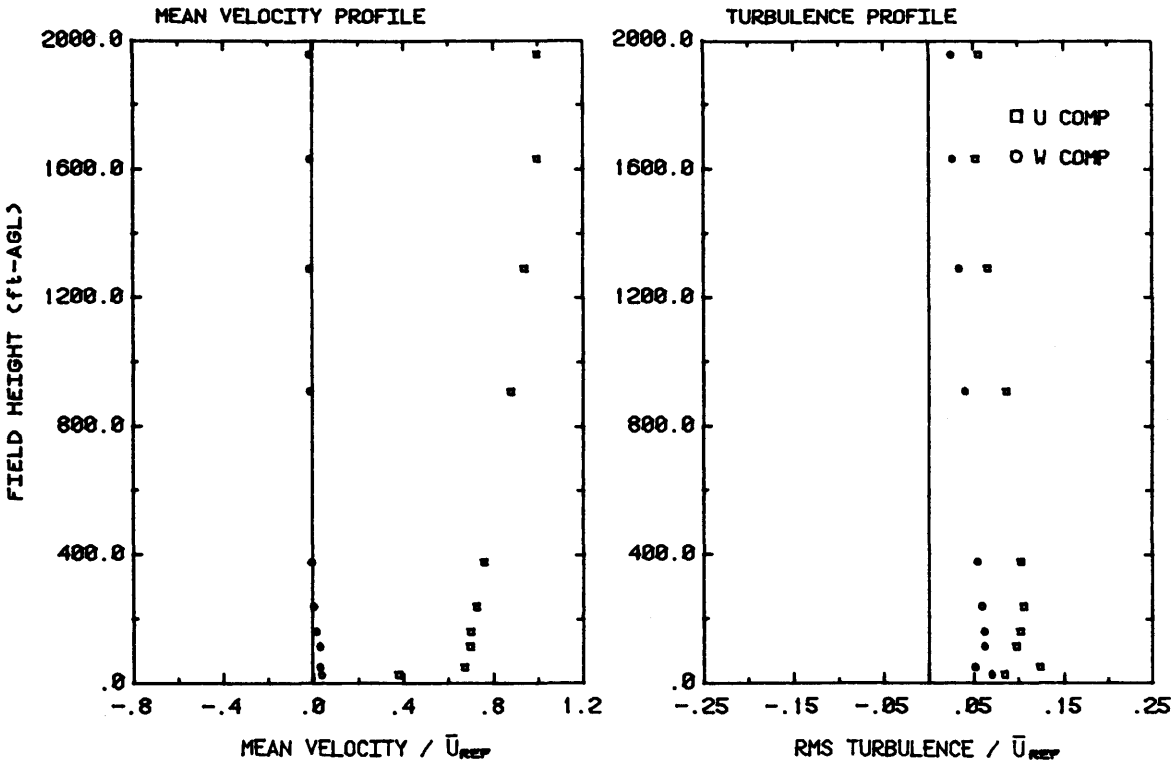


Figure D-3. Normalized mean velocities and turbulence intensity at location AN21 for the south (S) wind directon.

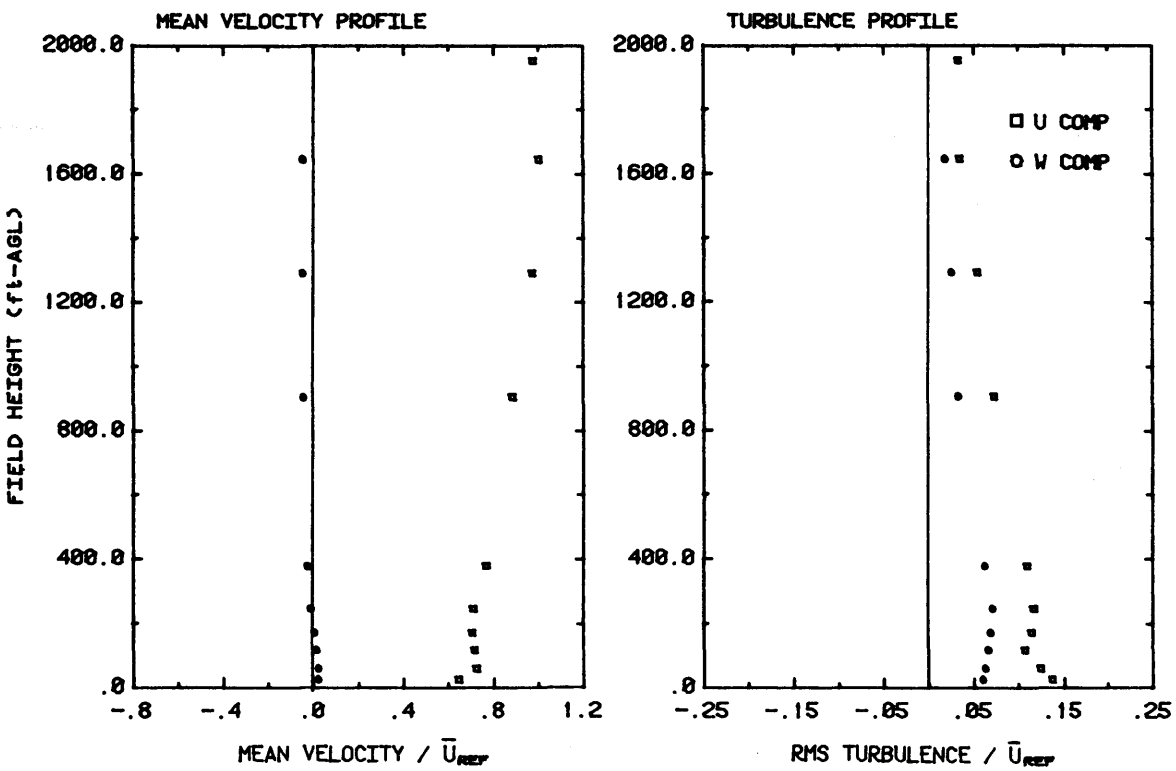


Figure D-4. Normalized mean velocities and turbulence intensity at location AN37 for the south (S) wind direction.

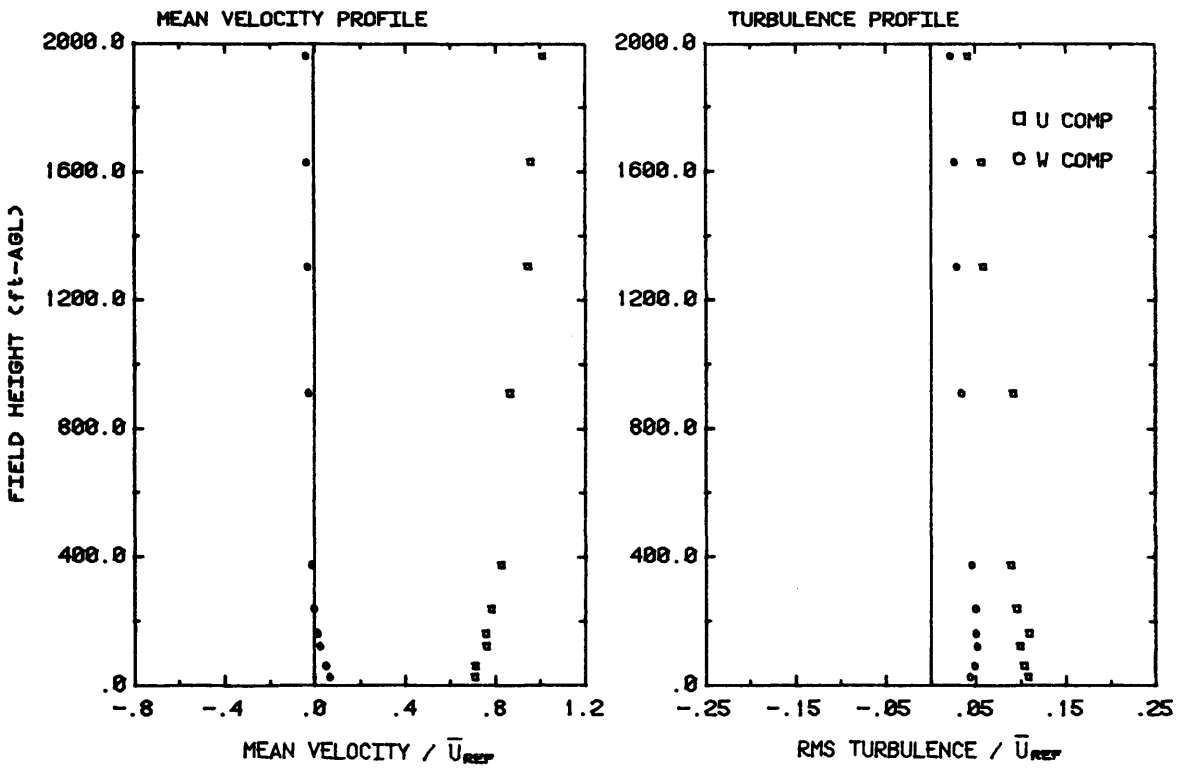


Figure D-5. Normalized mean velocities and turbulence intensity at location AN84 for the south (S) wind direction.

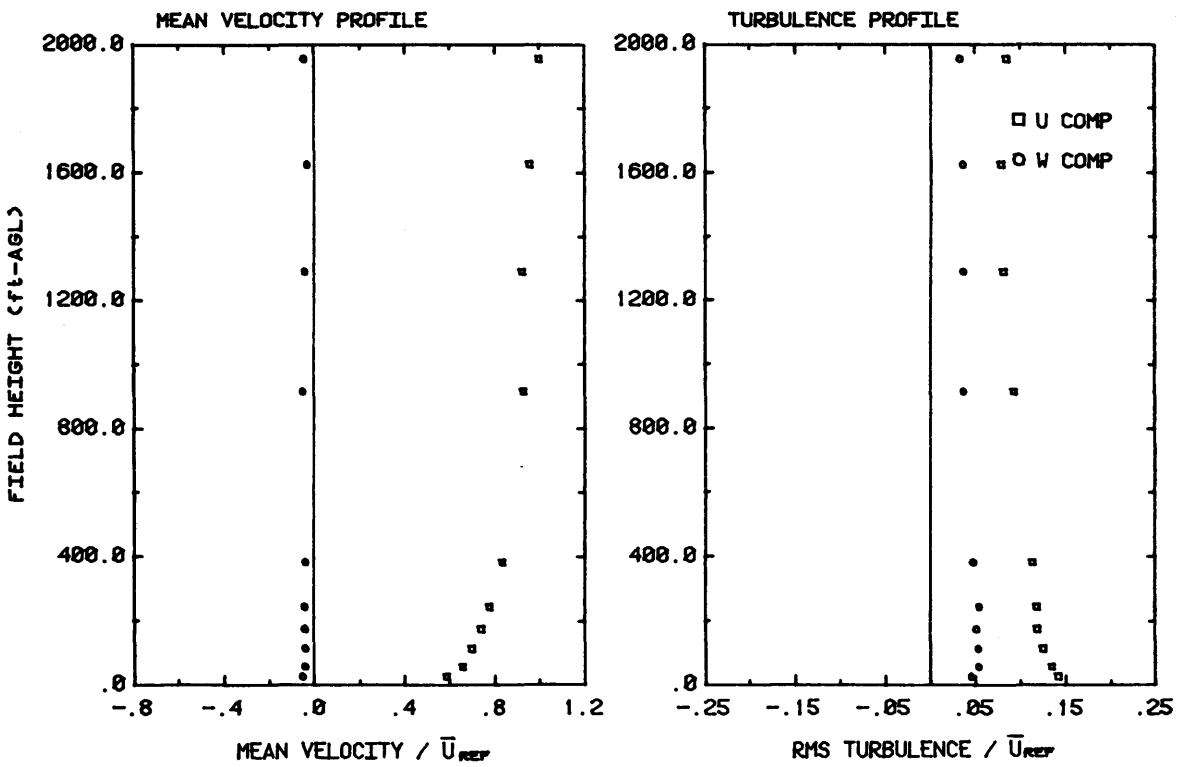


Figure D-6. Normalized mean velocities and turbulence intensity at location AN86 for the south (S) wind direction.

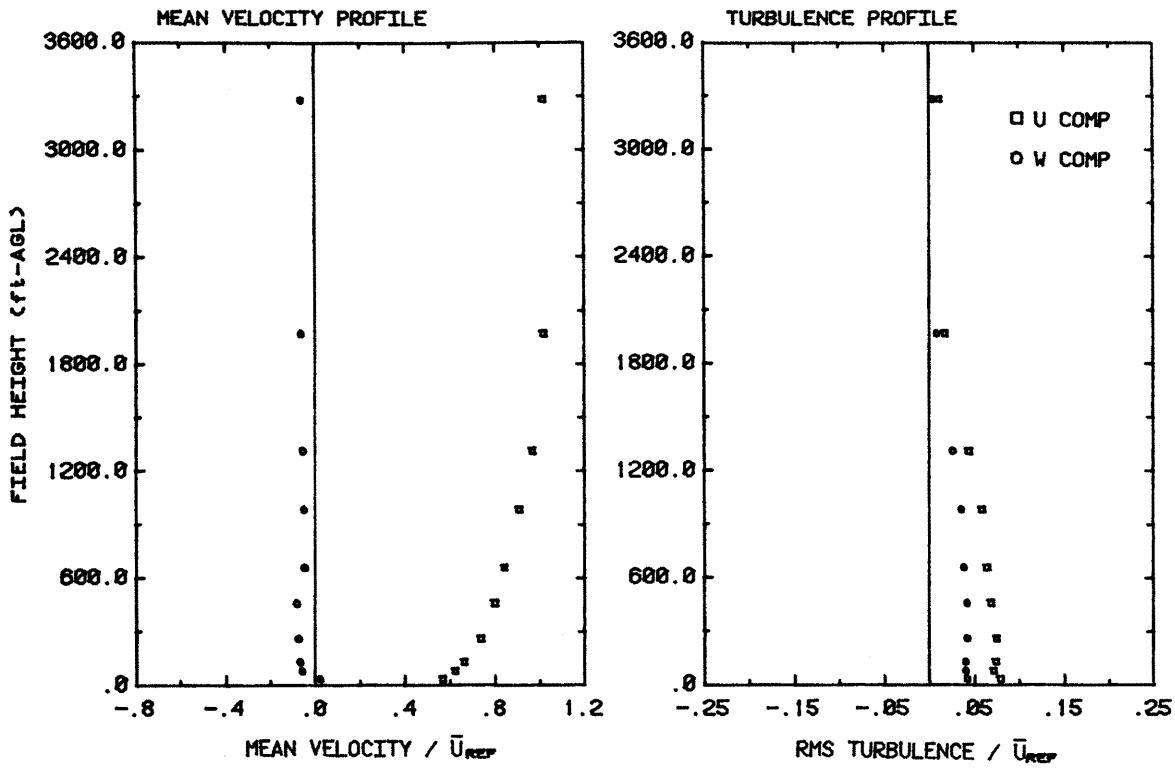


Figure D-7. Normalized mean velocities and turbulence intensity for HIA for the south southwest (SSW) wind direction.

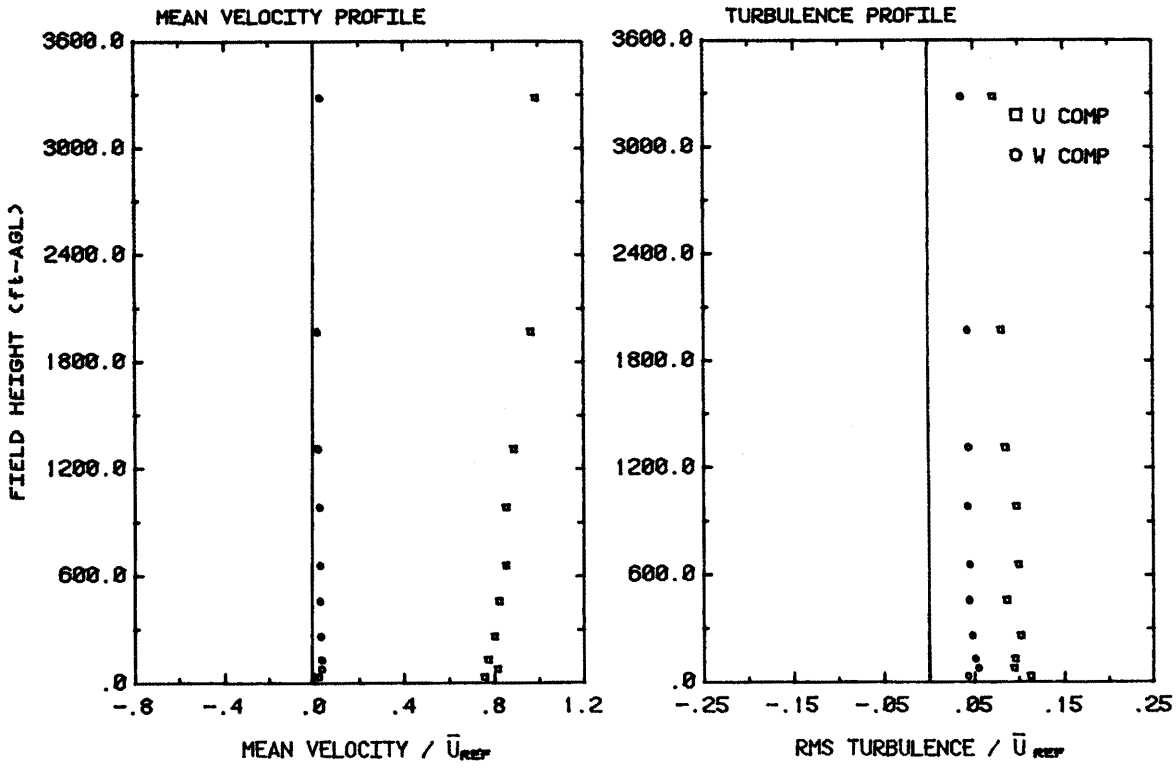


Figure D-8. Normalized mean velocities and turbulence intensity at location AN21 for the south southwest (SSW) wind direction.

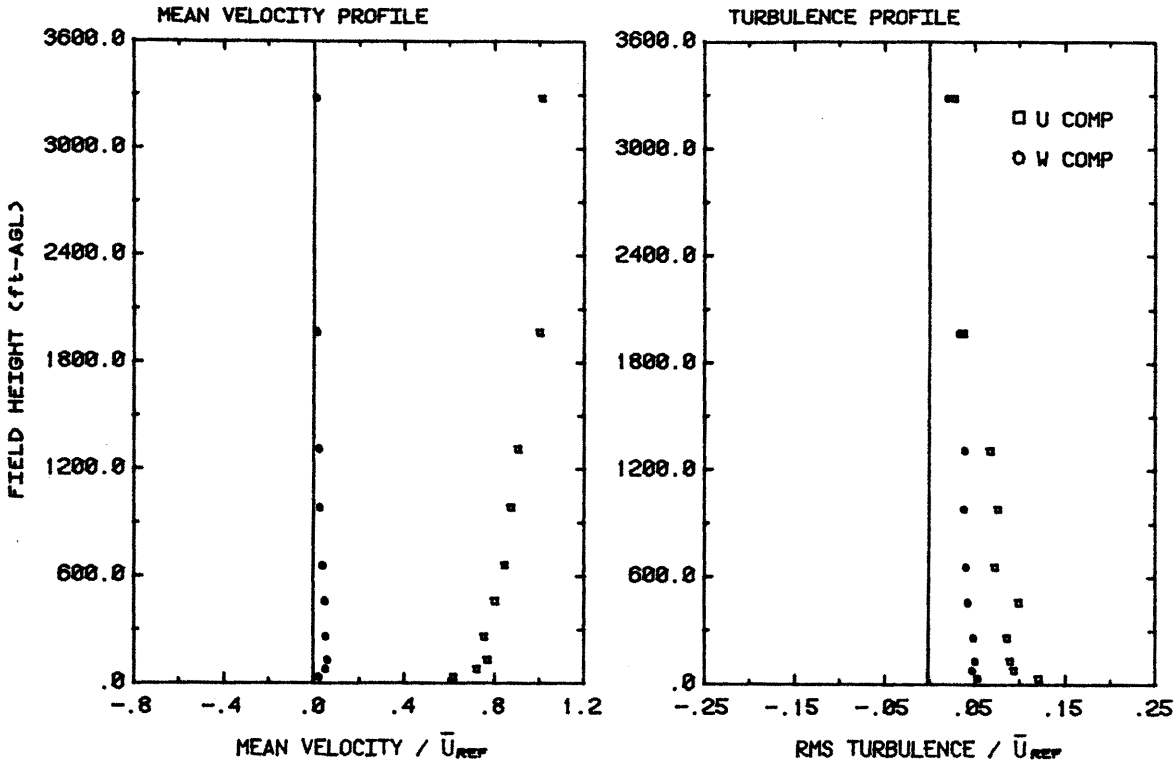


Figure D-9. Normalized mean velocities and turbulence intensity at location AN37 for the south southwest (SSW) wind direction.

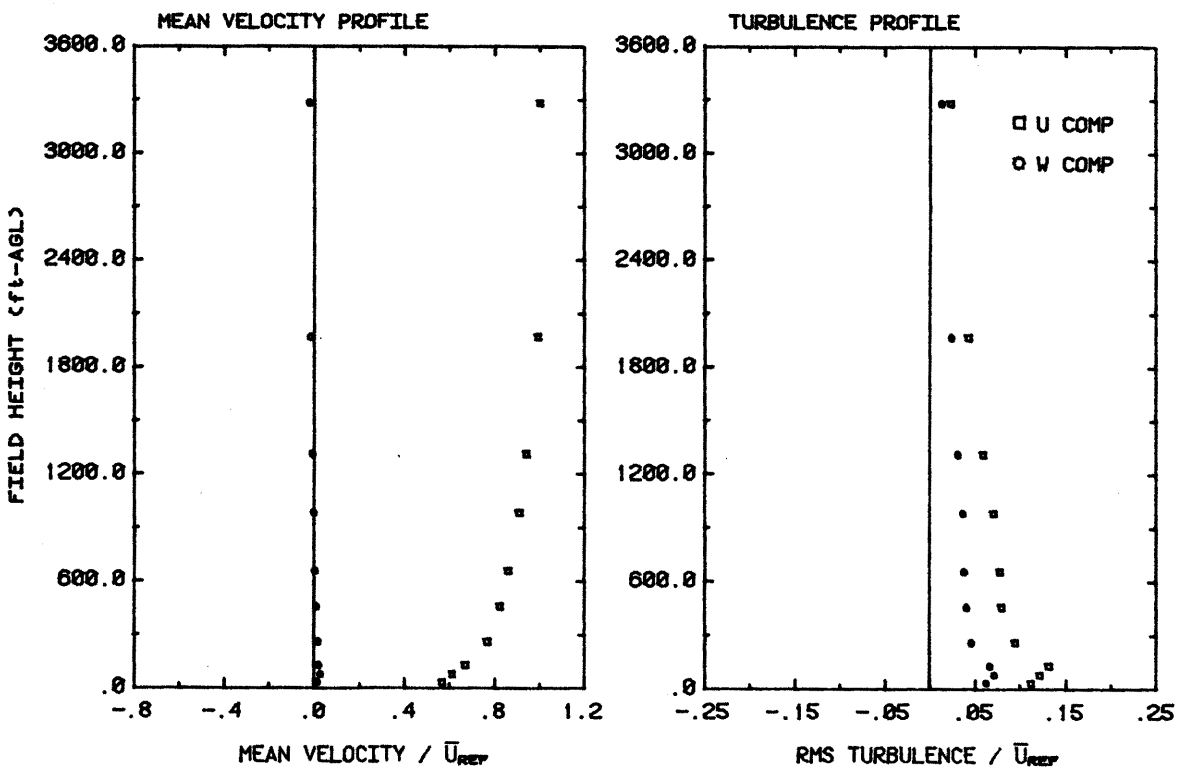


Figure D-10. Normalized mean velocities and turbulence intensity at location AN84 for the south southwest (SSW) wind direction.

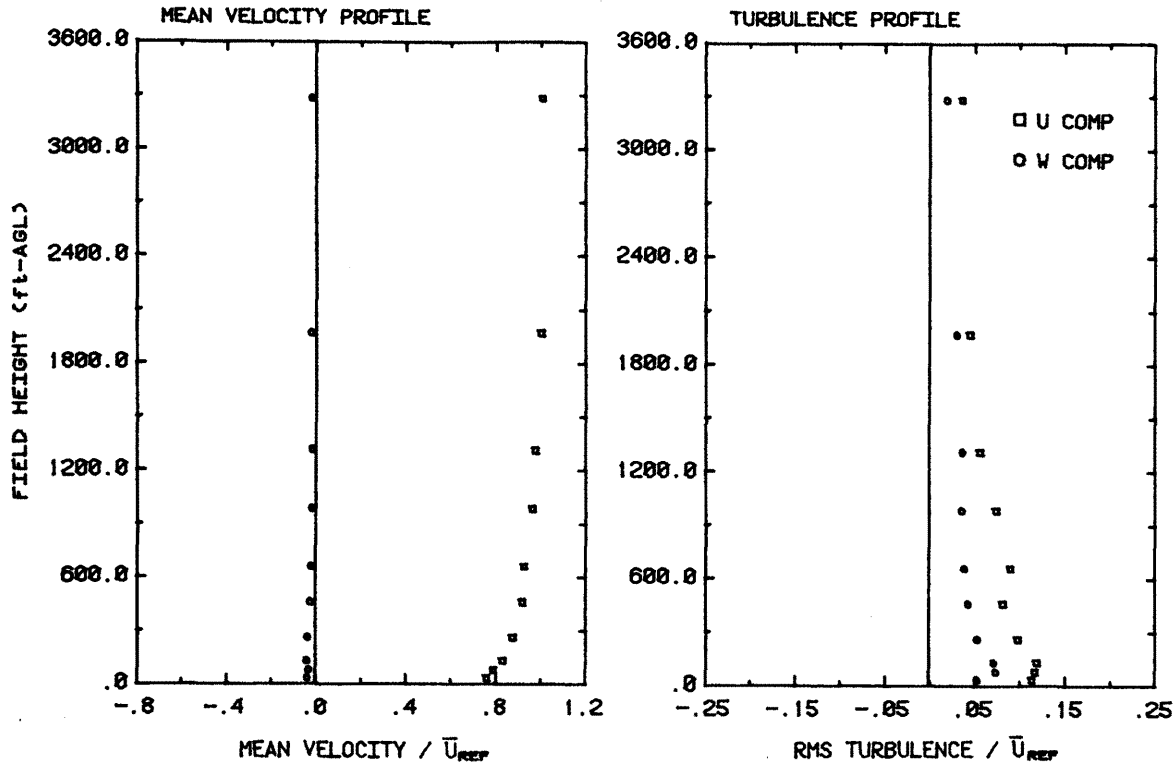


Figure D-11. Normalized mean velocities and turbulence intensity at location AN86 for the south southwest (SSW) wind direction.

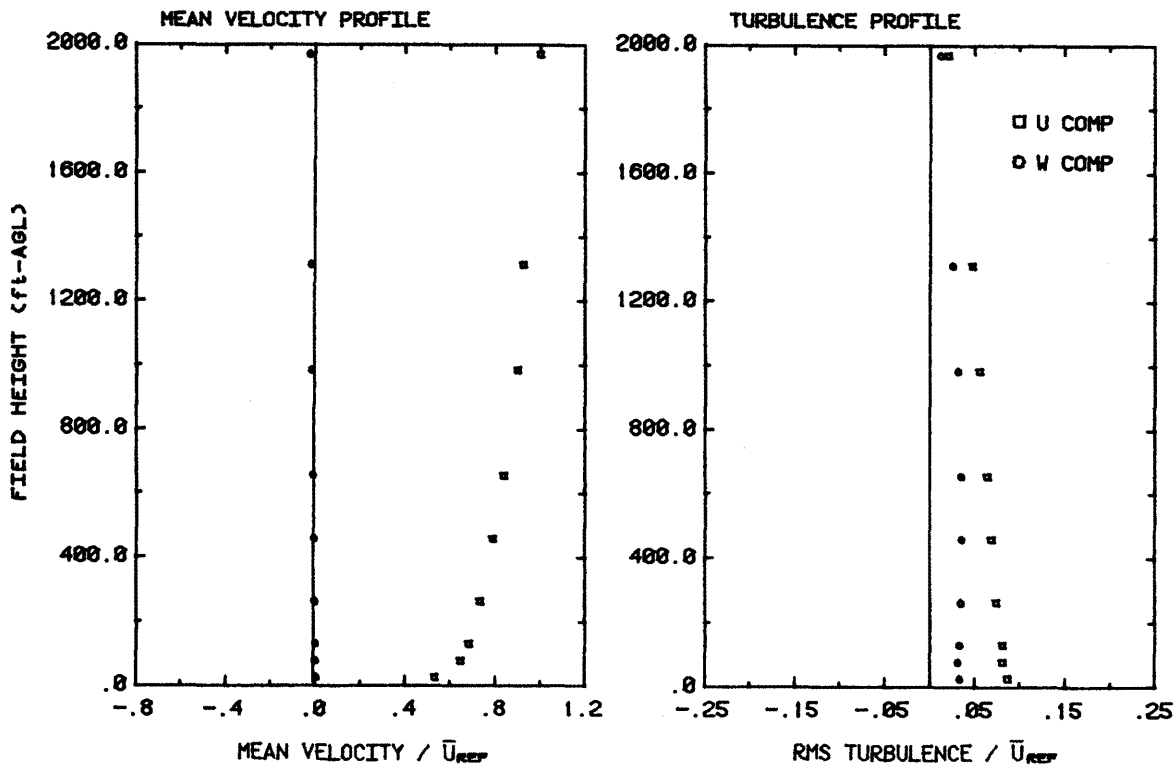


Figure D-12. Normalized mean velocities and turbulence intensity for HIA for the southwest (SW) wind direction.

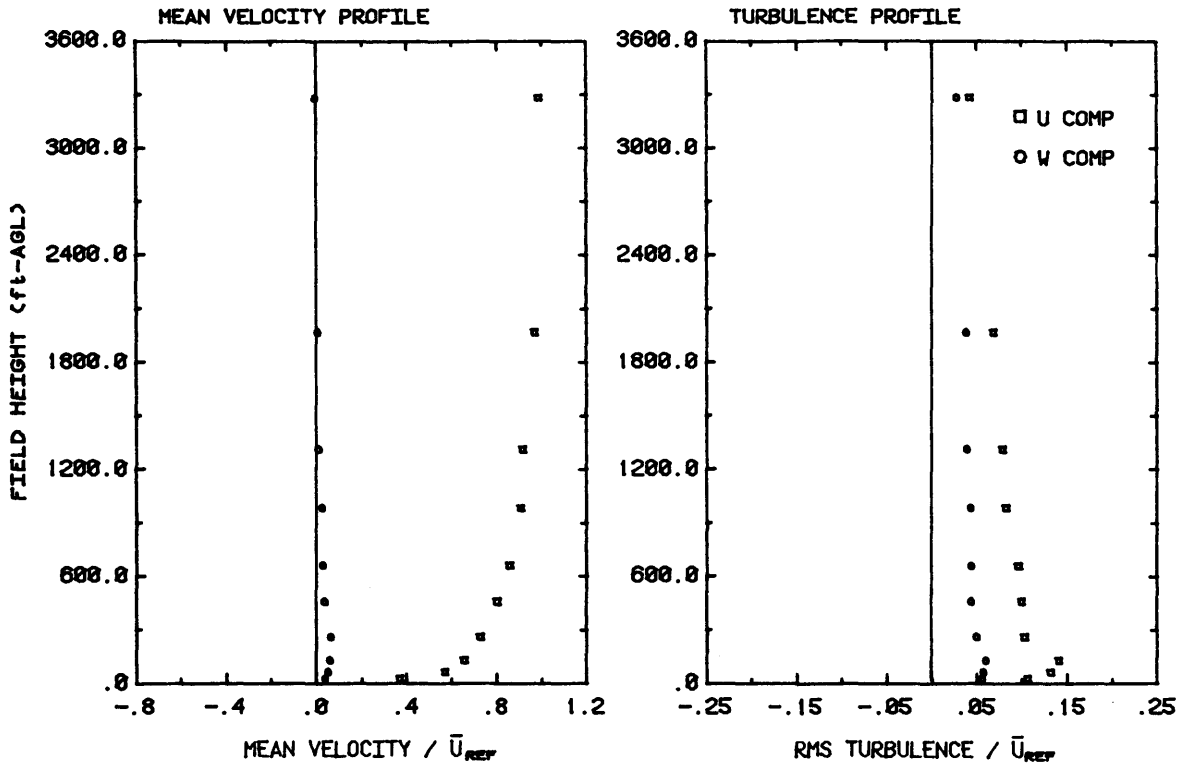


Figure D-13. Normalized mean velocities and turbulence intensity at location AN21 for the southwest (SW) wind direction.

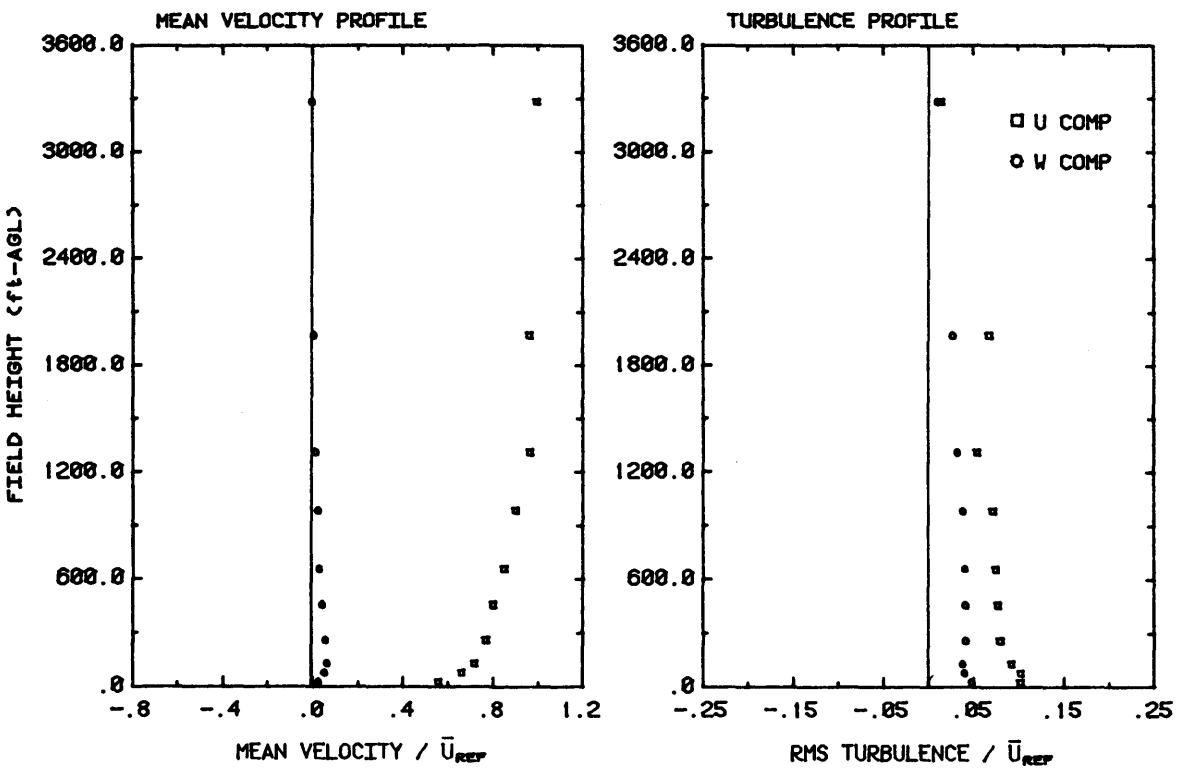


Figure D-14. Normalized mean velocities and turbulence intensity at location AN37 for the southwest (SW) wind direction.

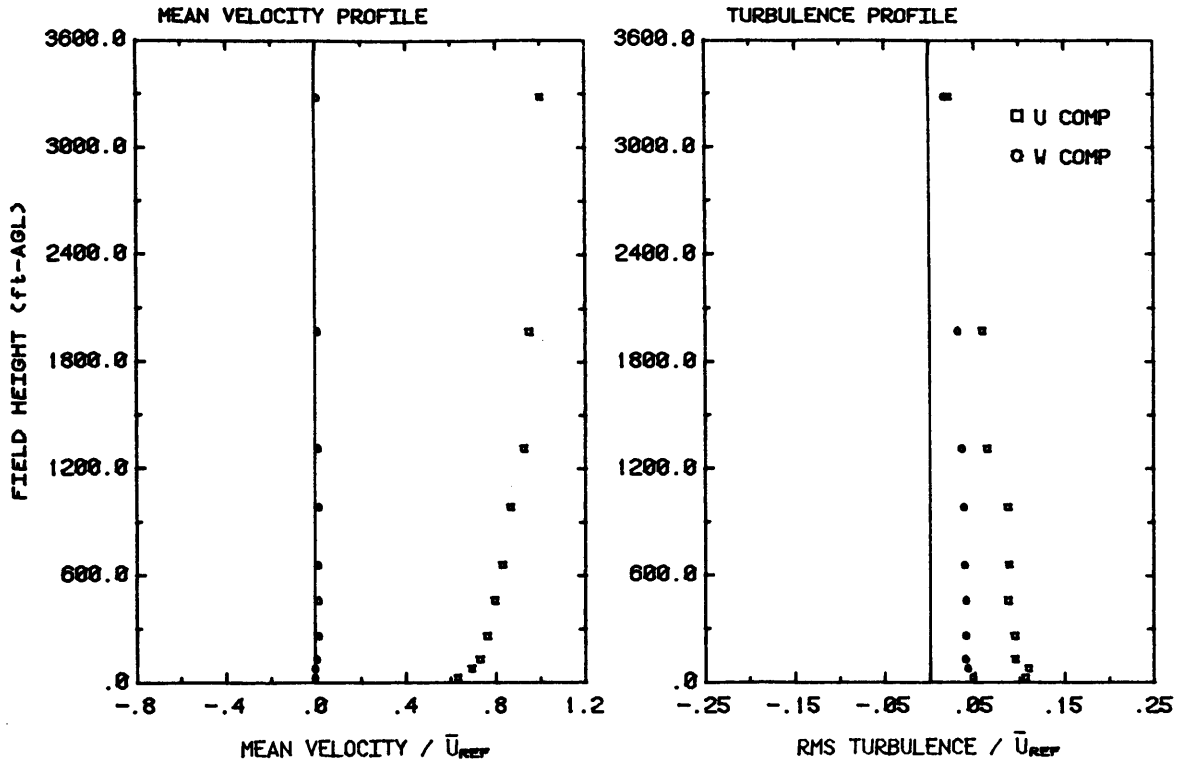


Figure D-15. Normalized mean velocities and turbulence intensity at location AN84 for the southwest (SW) wind direction.

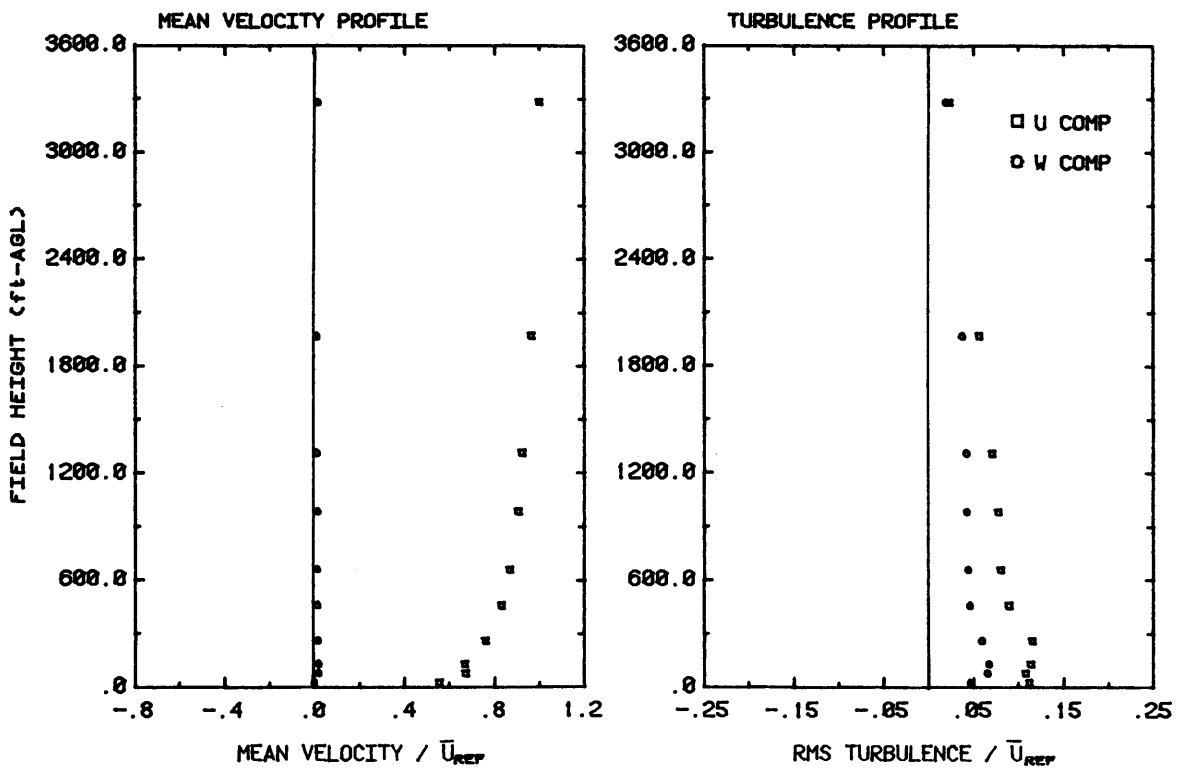


Figure D-16. Normalized mean velocities and turbulence intensity at location AN86 for the southwest (SW) wind direction.

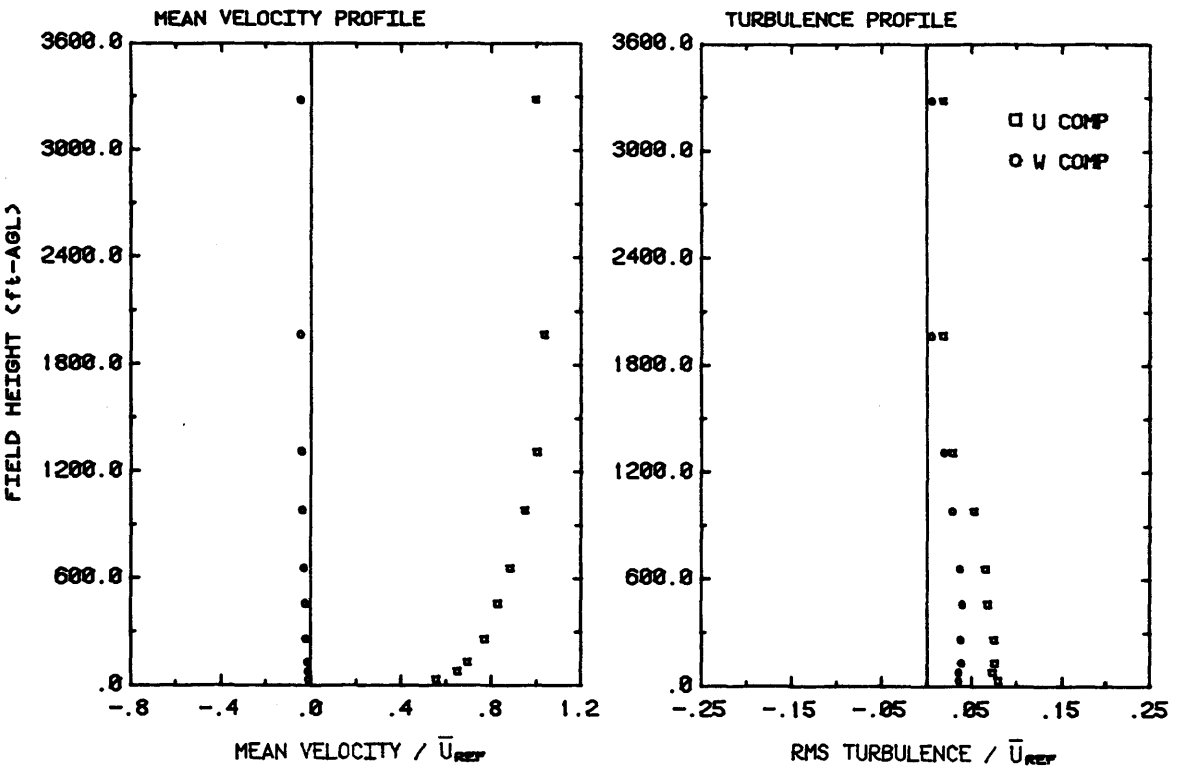


Figure D-17. Normalized mean velocities and turbulence intensity for BPA for the west southwest (WSW) wind direction.

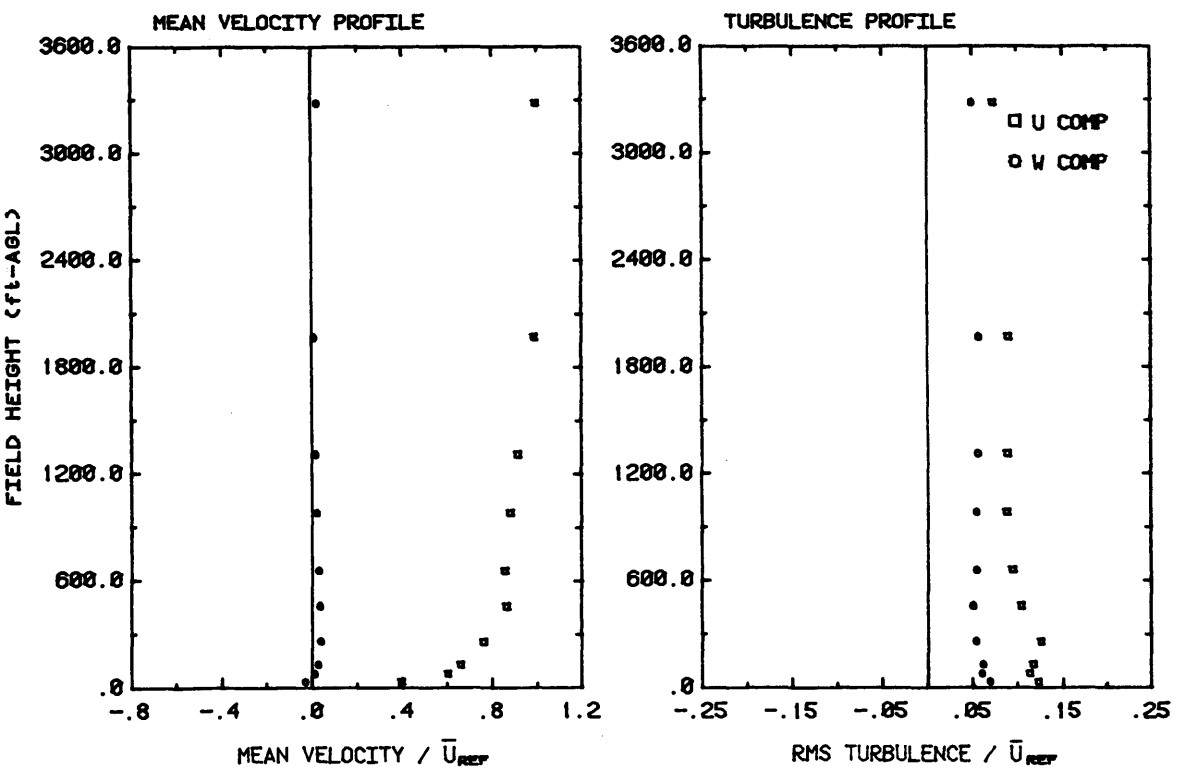


Figure D-18. Normalized mean velocities and turbulence intensity at location AN21 for the west southwest (WSW) wind direction.

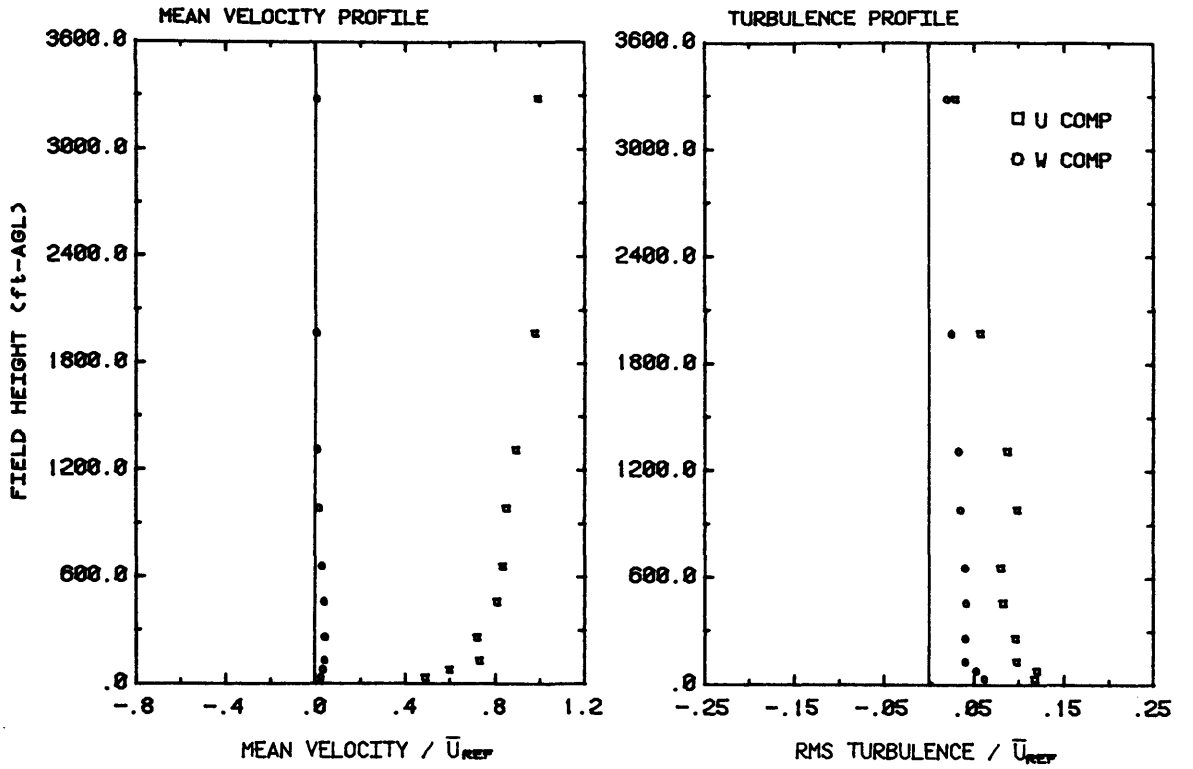


Figure D-19. Normalized mean velocities and turbulence intensity at location AN37 for the west southwest (WSW) wind direction.

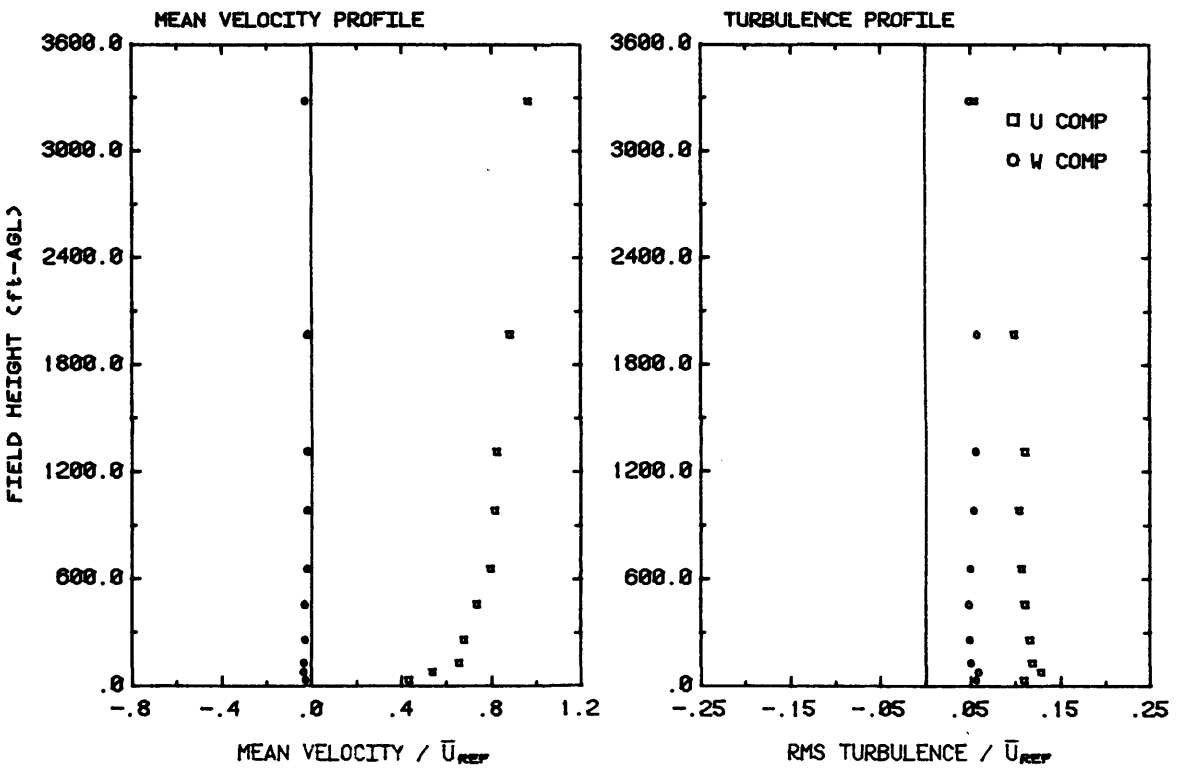


Figure D-20. Normalized mean velocities and turbulence intensity at location AN84 for the west southwest (WSW) wind direction.

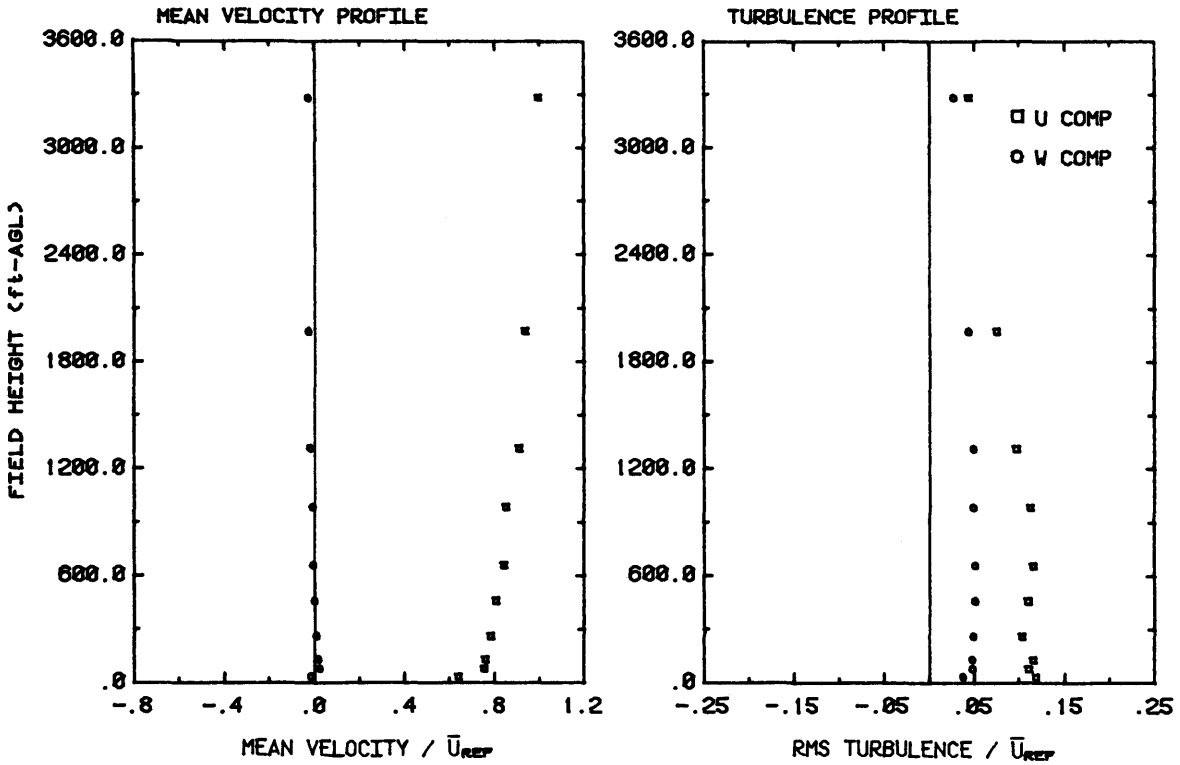


Figure D-21. Normalized mean velocities and turbulence intensity at location AN86 for the west southwest (WSW) wind direction.

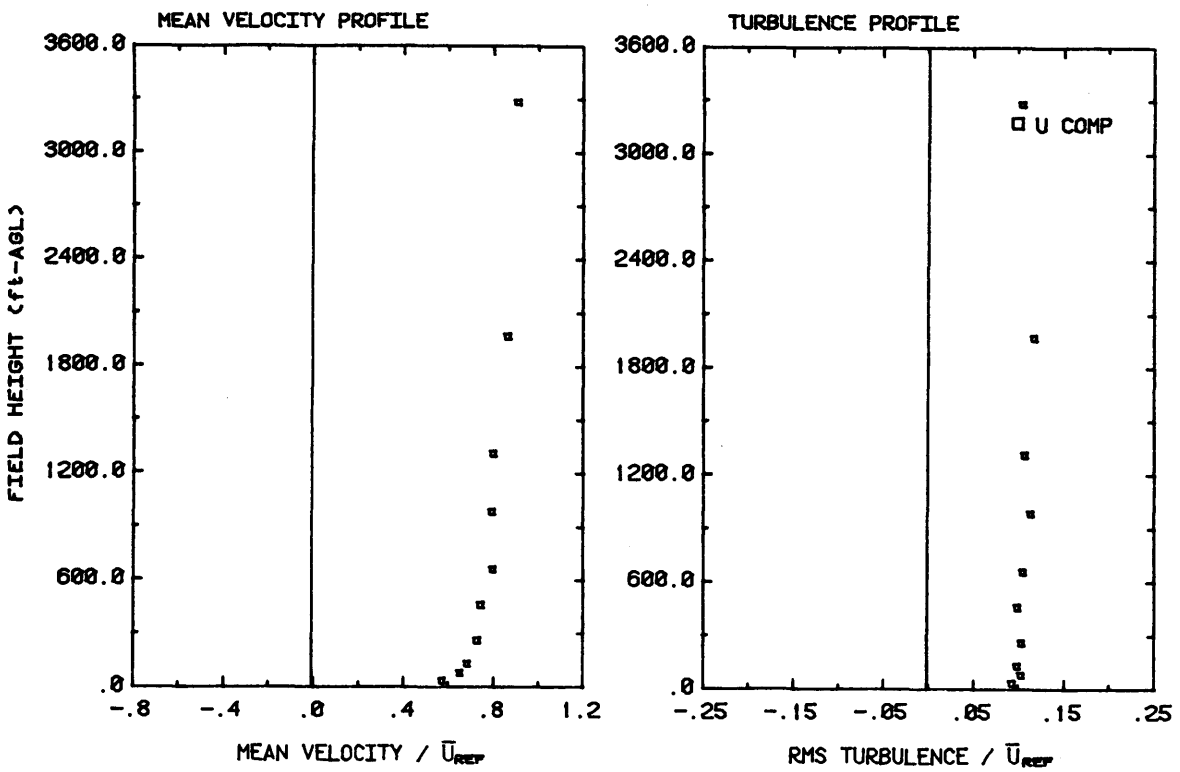


Figure D-22. Normalized mean velocities and turbulence intensity for HIA for the north northeast (NNE) wind direction.

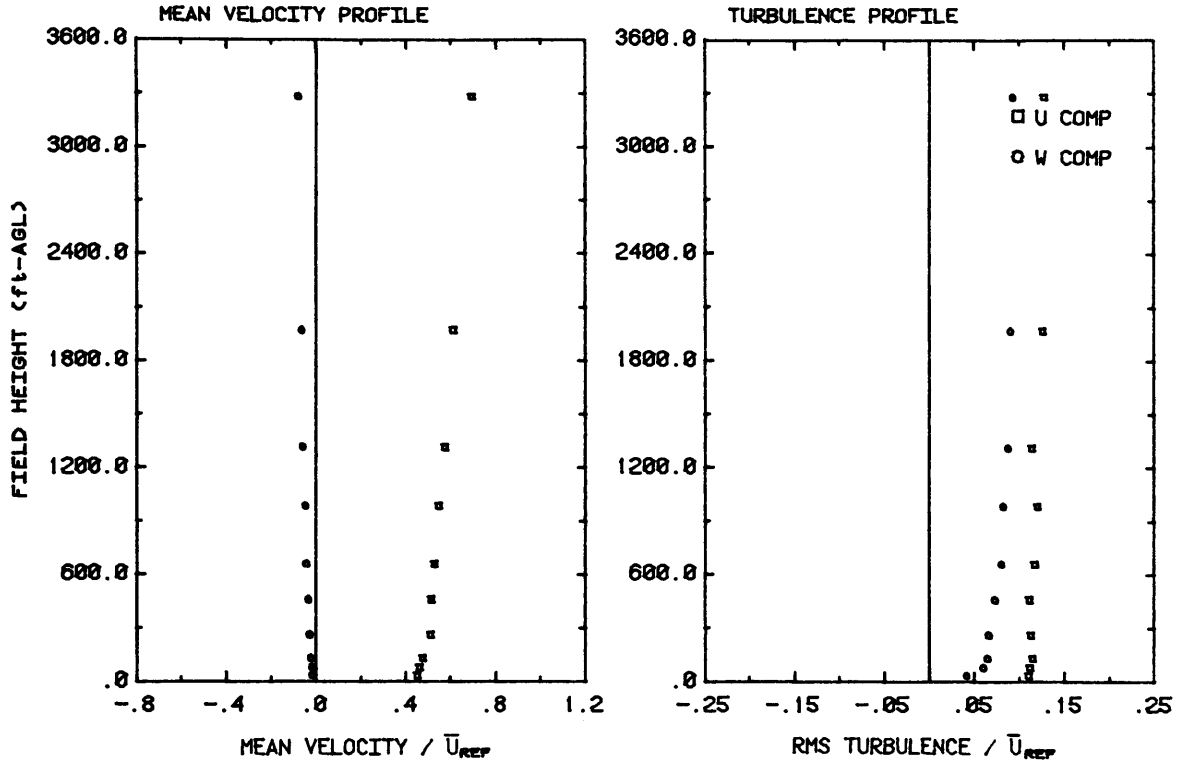


Figure D-23. Normalized mean velocities and turbulence intensity at location AN21 for the north northeast (NNE) wind direction.

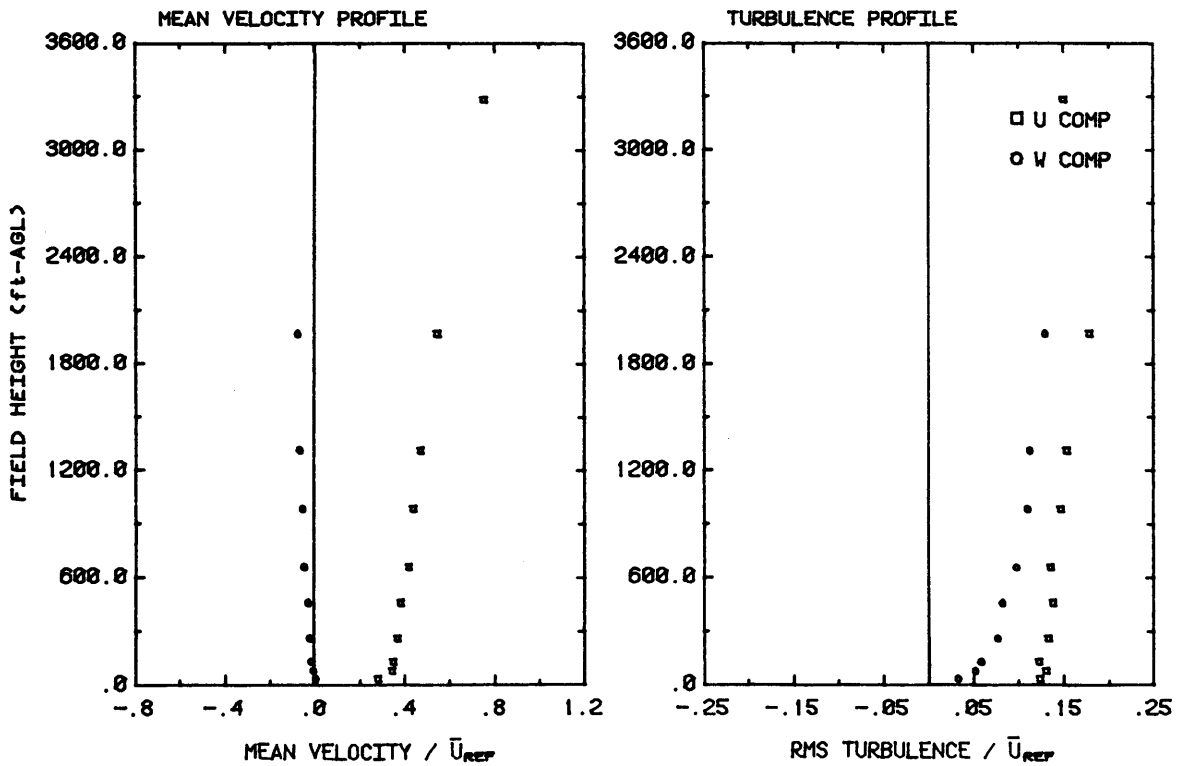


Figure D-24. Normalized mean velocities and turbulence intensity at location AN37 for the north northeast (NNE) wind direction.

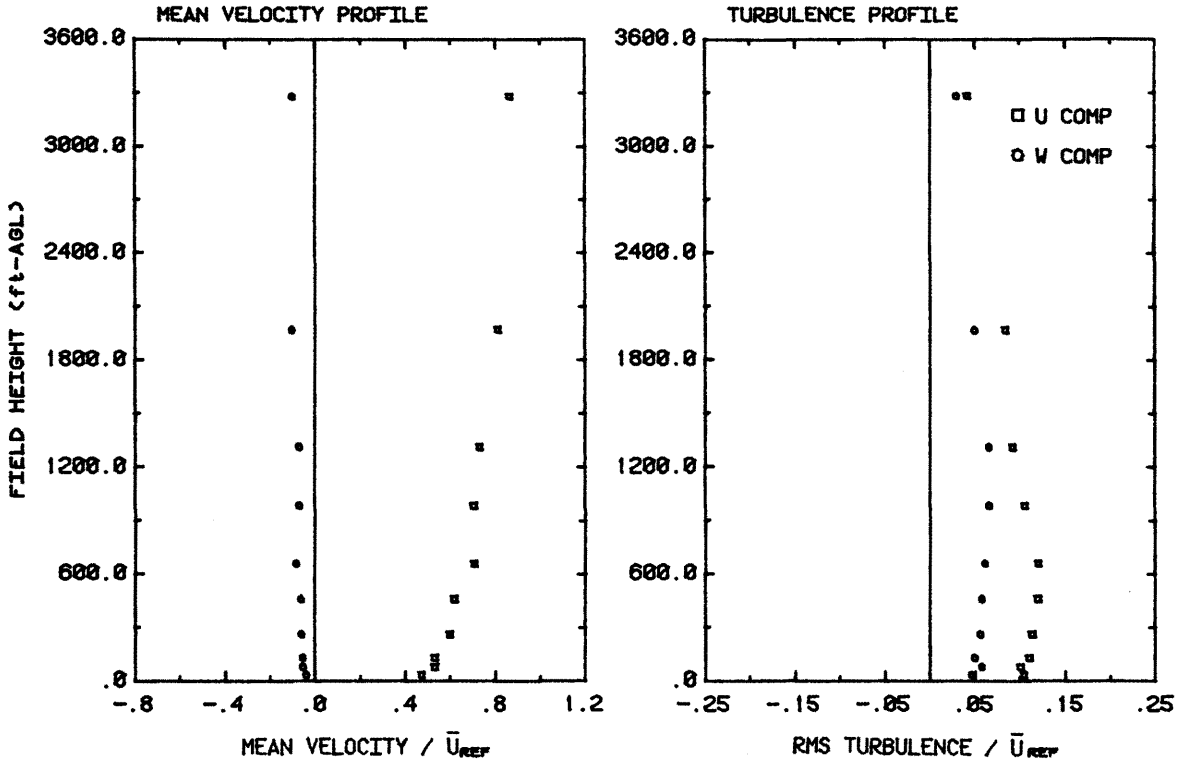


Figure D-25. Normalized mean velocities and turbulence intensity at location AN84 for the north northeast (NNE) wind direction.

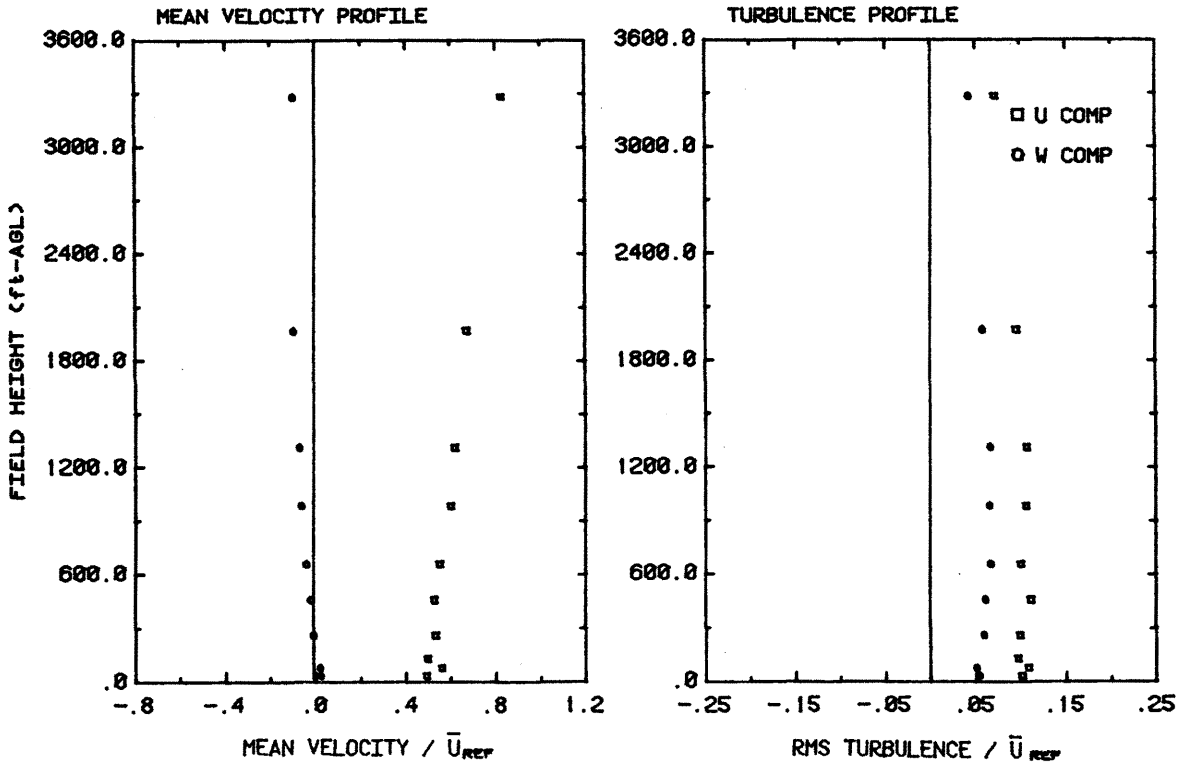


Figure D-26. Normalized mean velocities and turbulence intensity at location AN86 for the north northeast (NNE) wind direction.

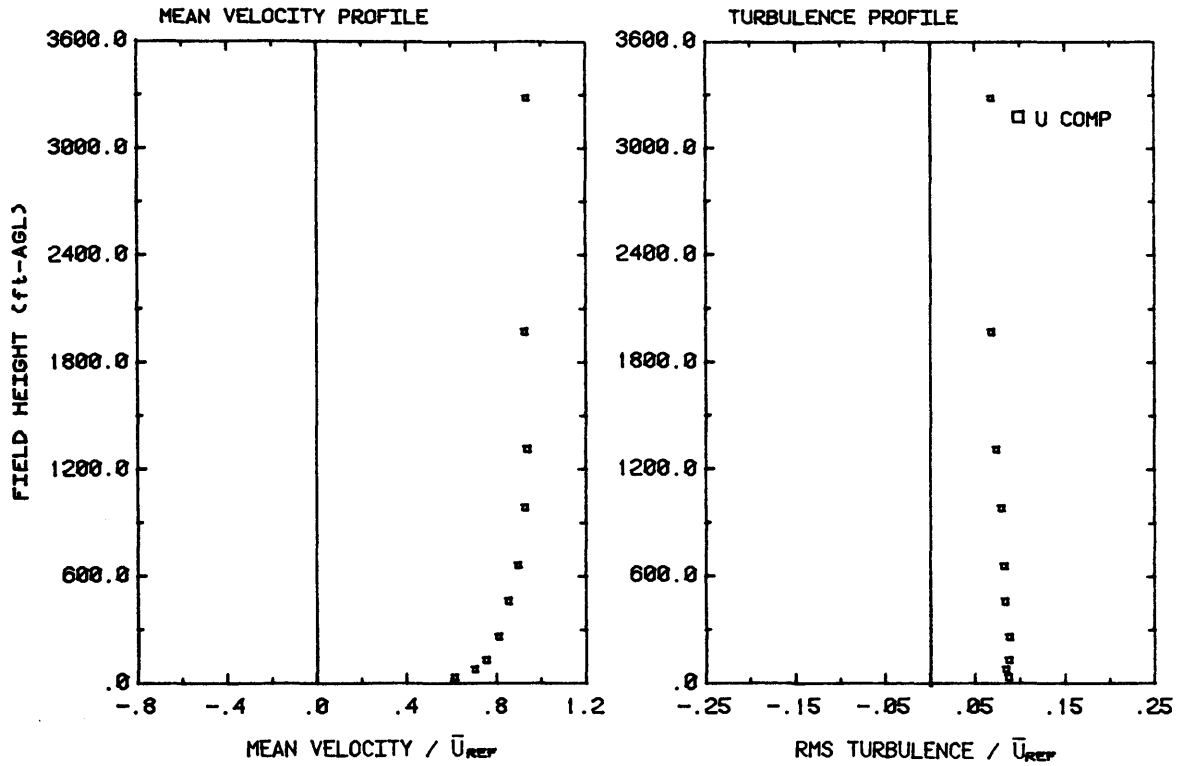


Figure D-27. Normalized mean velocities and turbulence intensity for BPA for the east northeast (ENE) wind direction.

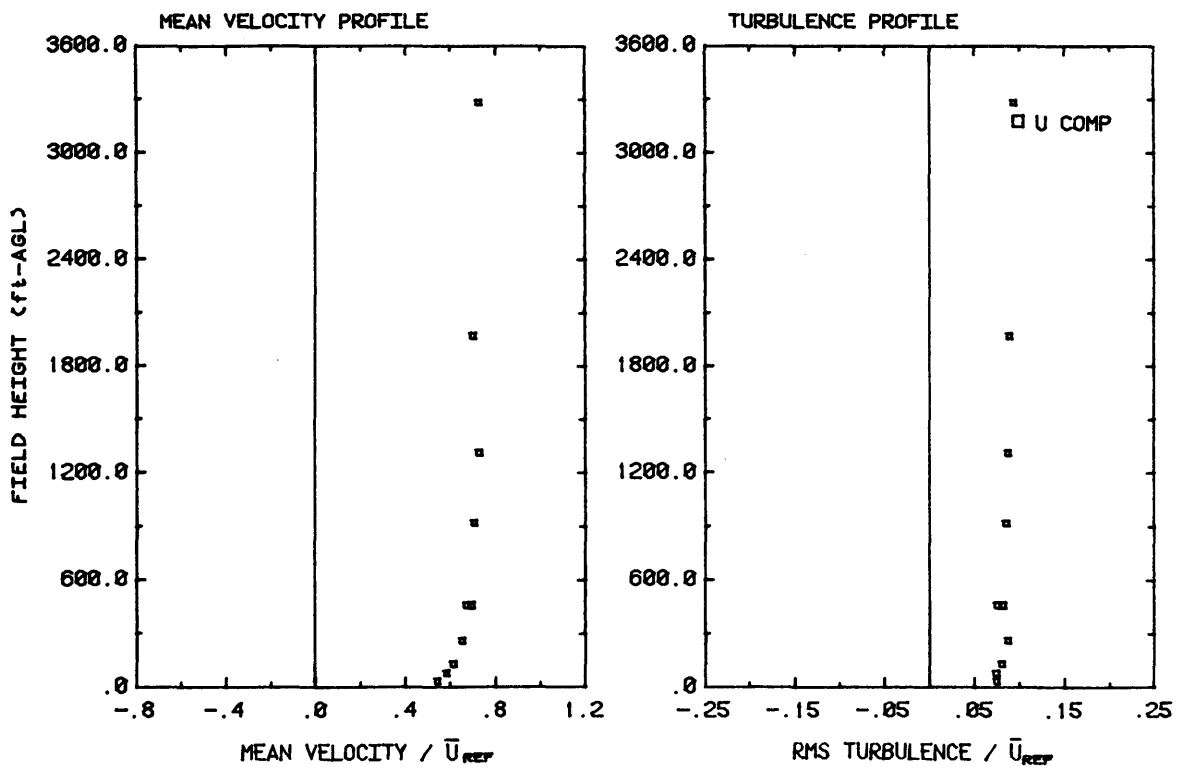


Figure D-28. Normalized mean velocities and turbulence intensity for HIA for the east northeast (ENE) wind direction.

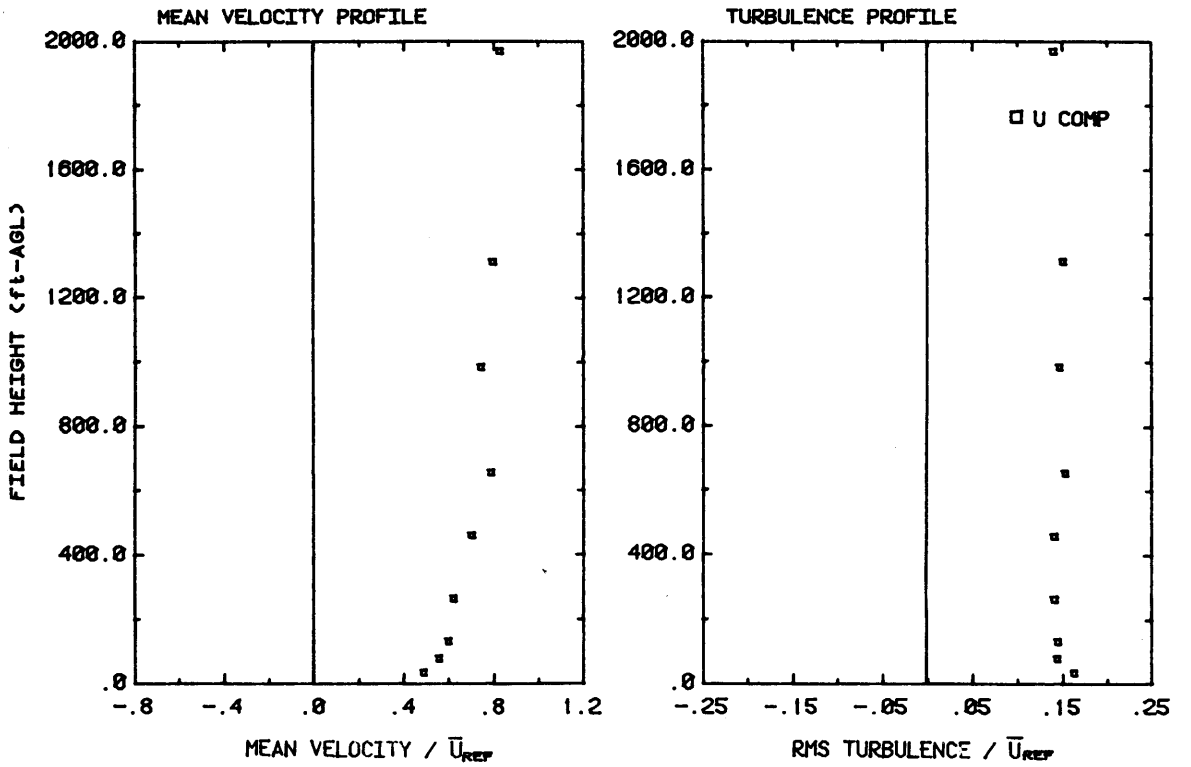


Figure D-29. Normalized mean velocities and turbulence intensity at location AN21 for the east northeast (ENE) wind direction.

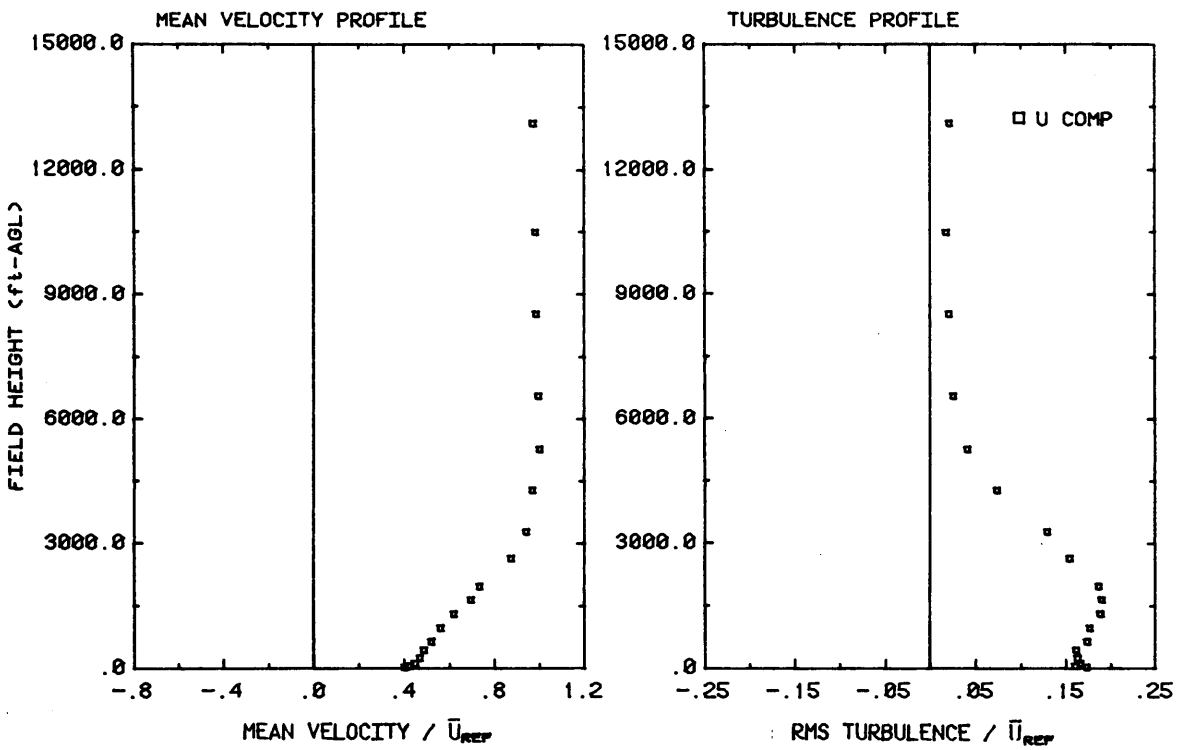


Figure D-30. Normalized mean velocities and turbulence intensity at location AN37 for the east northeast (ENE) wind direction.

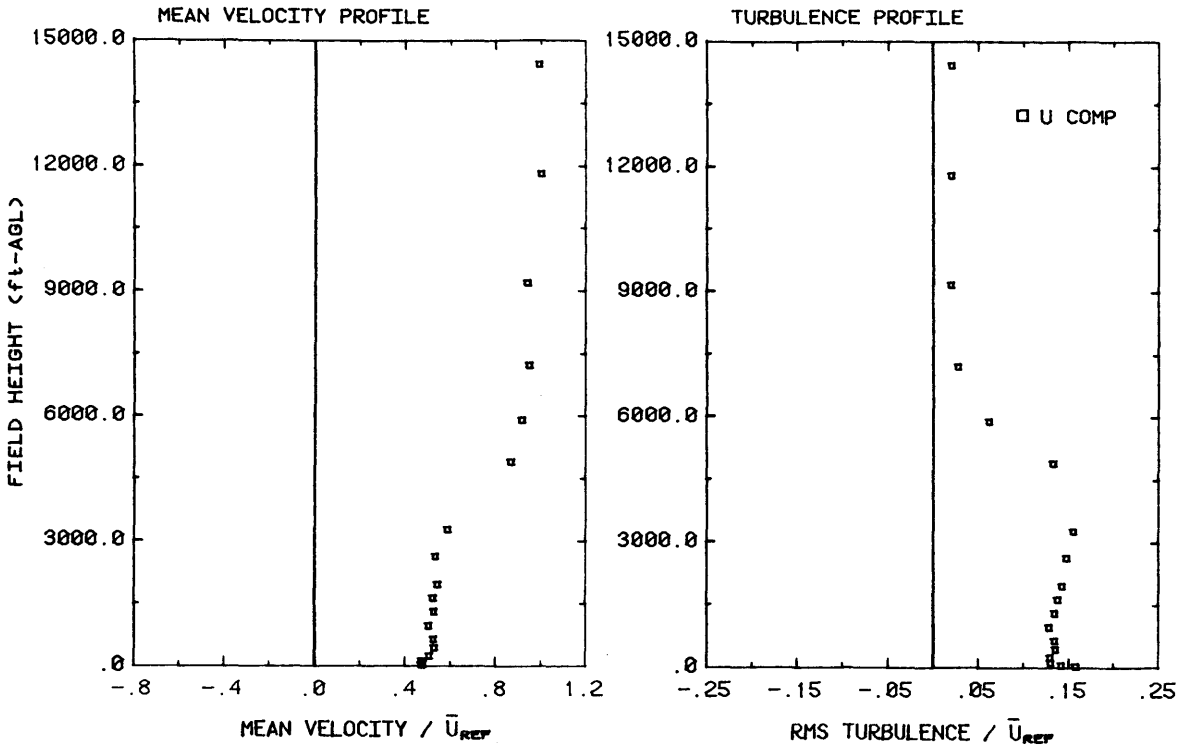


Figure D-31. Normalized mean velocities and turbulence intensity at location AN84 for the east northeast (ENE) wind direction.

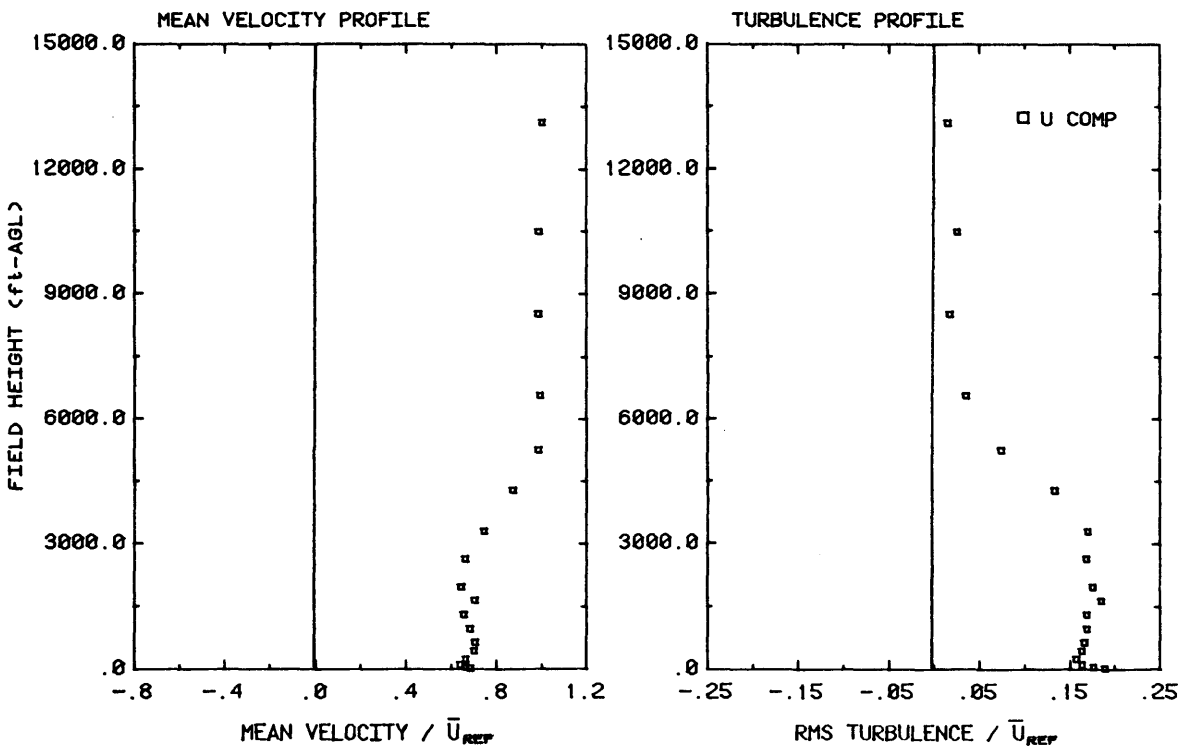


Figure D-32. Normalized mean velocities and turbulence intensity at location AN86 for the east northeast (ENE) wind direction.

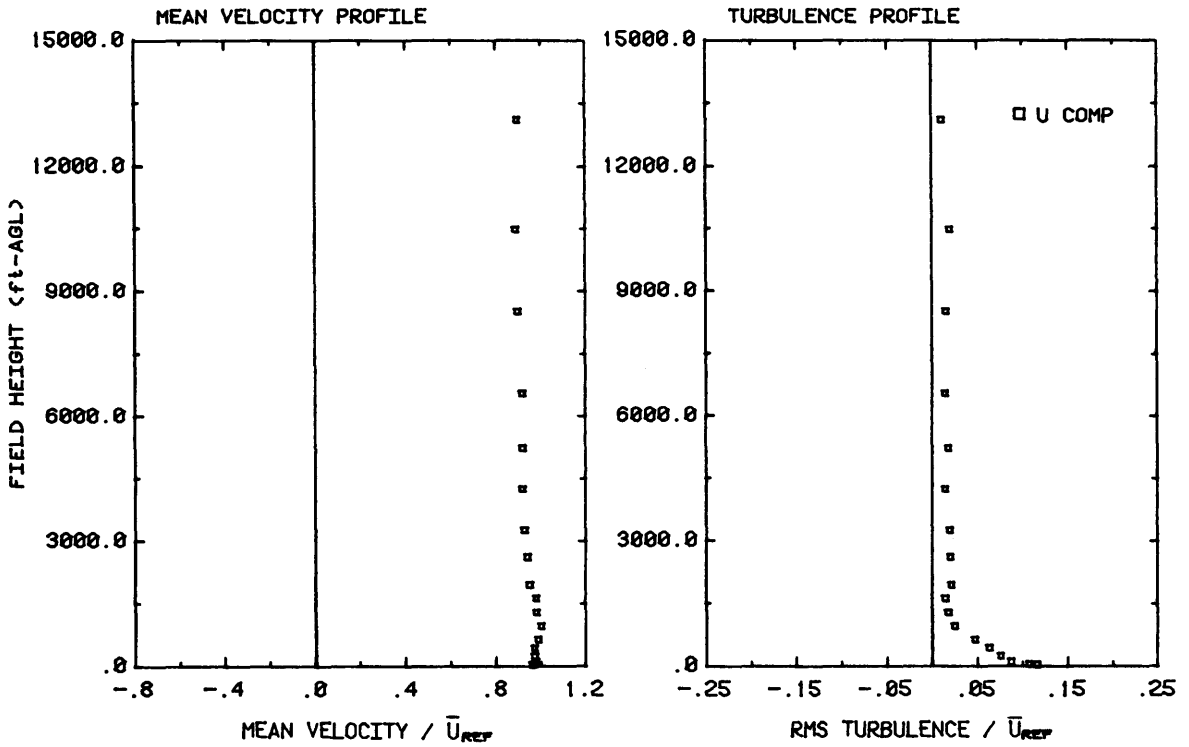


Figure D-33. Normalized mean velocities and turbulence intensity at the top of Koolau Range for the east northeast (ENE) wind direction.

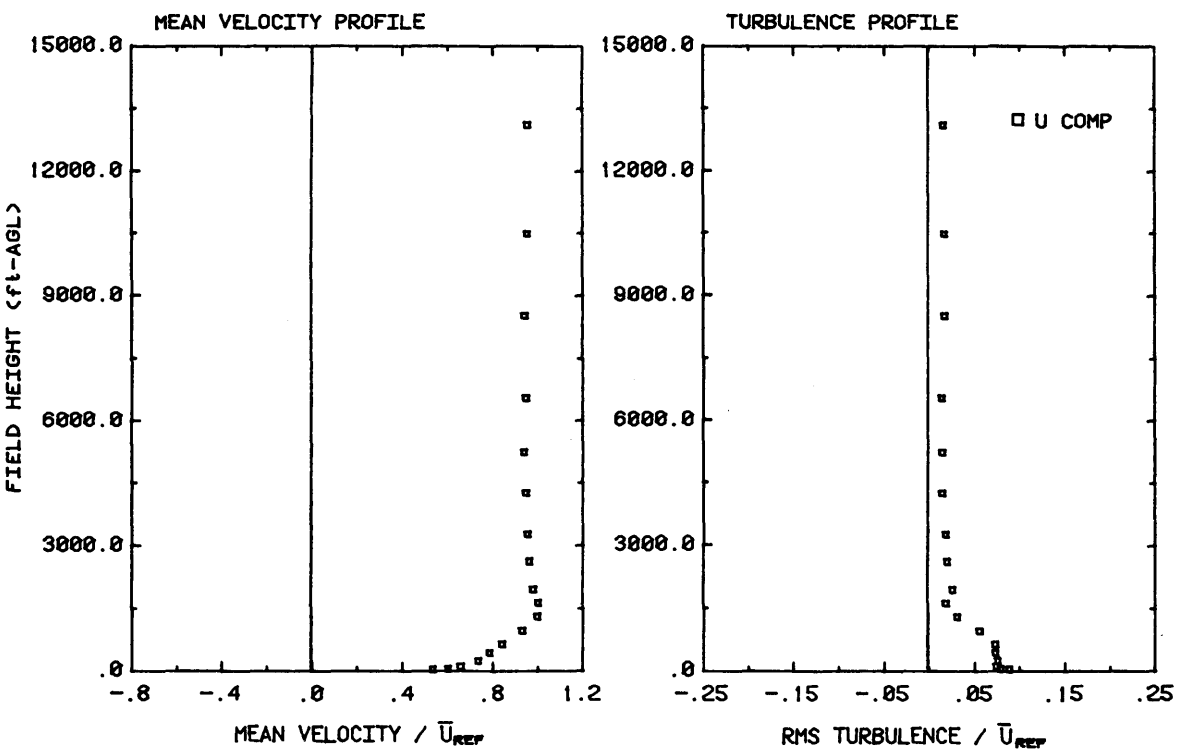


Figure D-34. Normalized mean velocities and turbulence intensity over shoreline, upwind of Koolau Range for the east northeast (ENE) wind direction.

APPENDIX E

VELOCITY AND TURBULENCE INTENSITY PROFILES AT TRANSMISSION LINE POINTS

Profiles are only plotted for locations with data for three or more elevations. Data for the locations with less than three elevations are tabulated in Appendix G.

Velocity components are plotted according to the transmission-line coordinate system (refer to Fig. C-2a). In some cases the u and v components overlap and are superpositioned in the figures of this appendix.

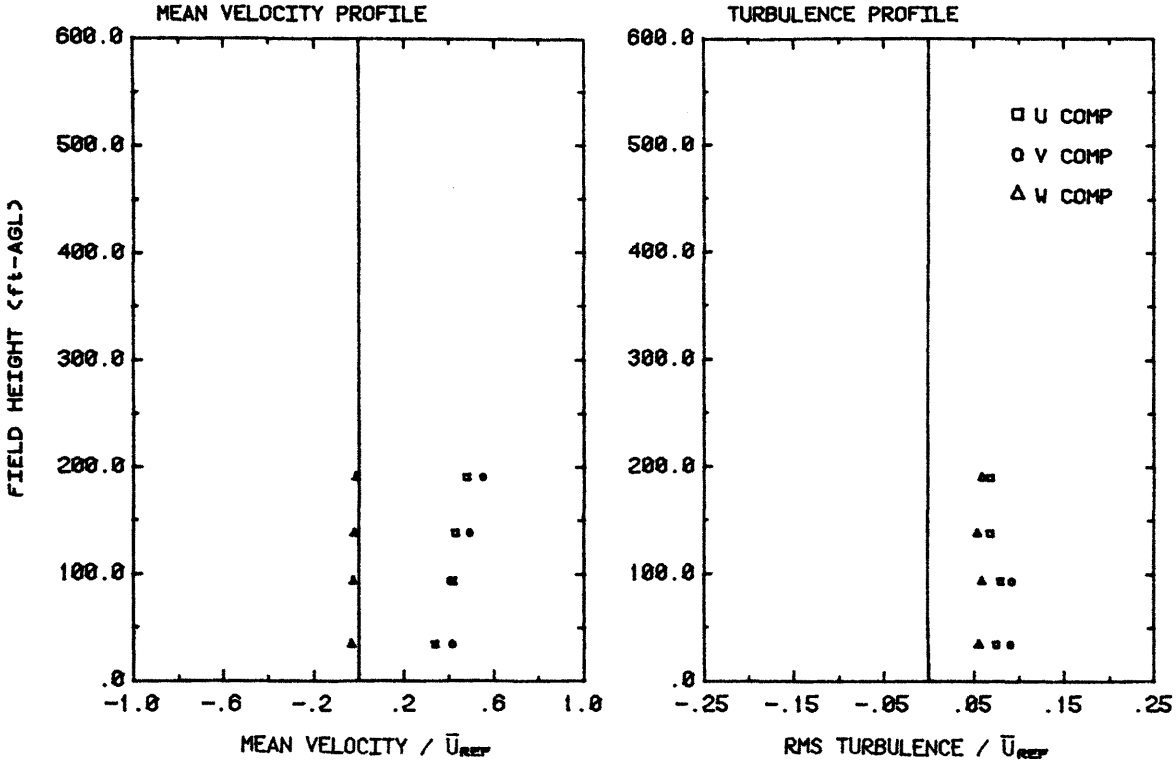


Figure E-1. Normalized mean velocities and turbulence intensity at location A1 for the south (S) wind direction.

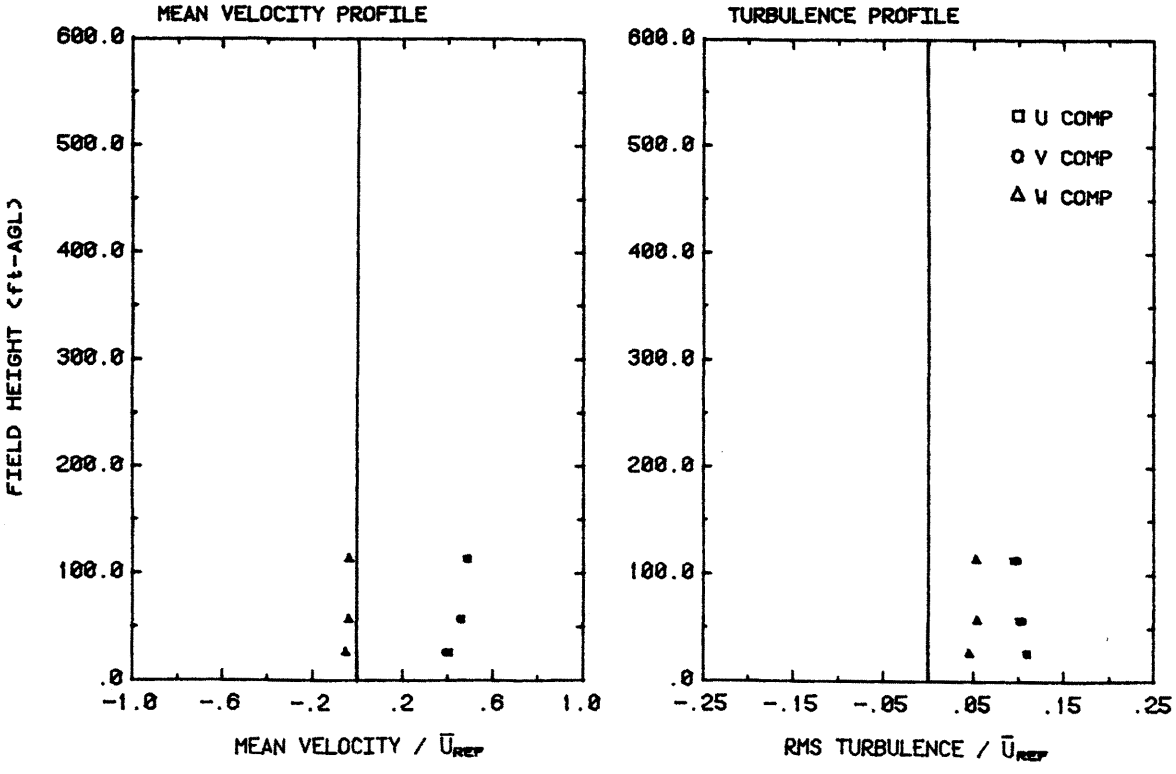


Figure E-2. Normalized mean velocities and turbulence intensity at location A5 for the south (S) wind direction.

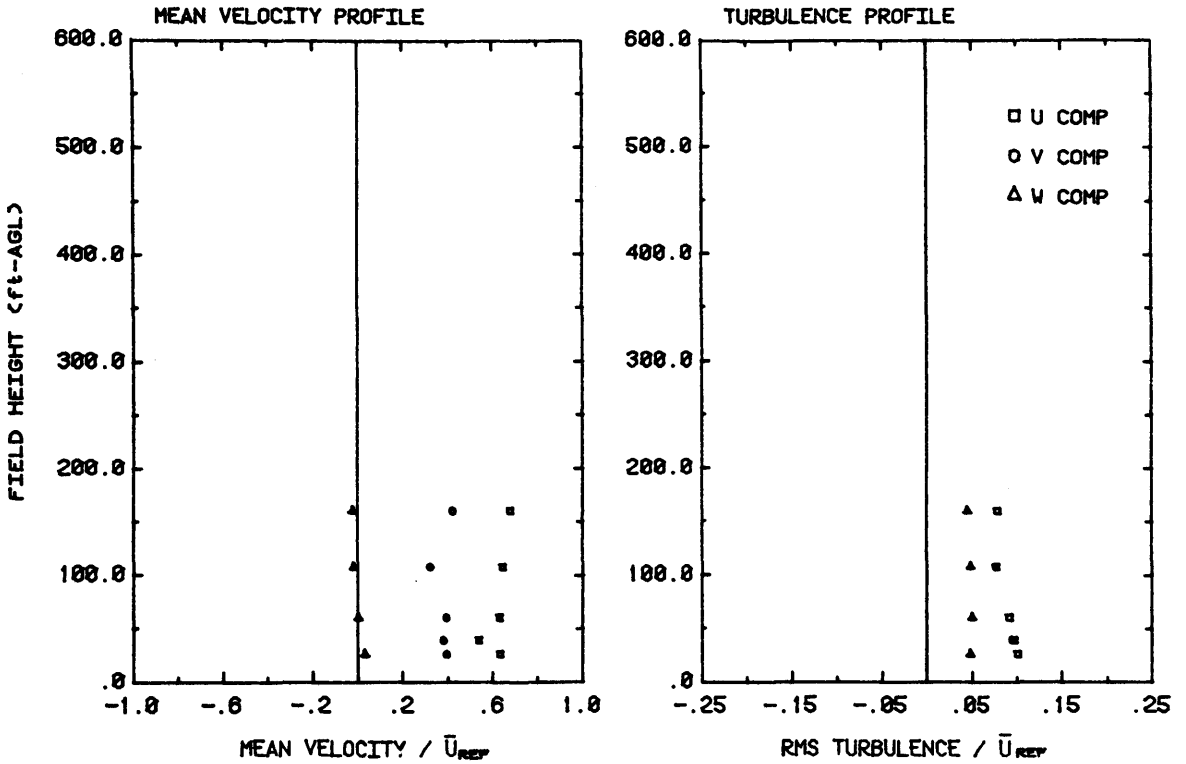


Figure E-3. Normalized mean velocities and turbulence intensity at location B1 for the south (S) wind direction.

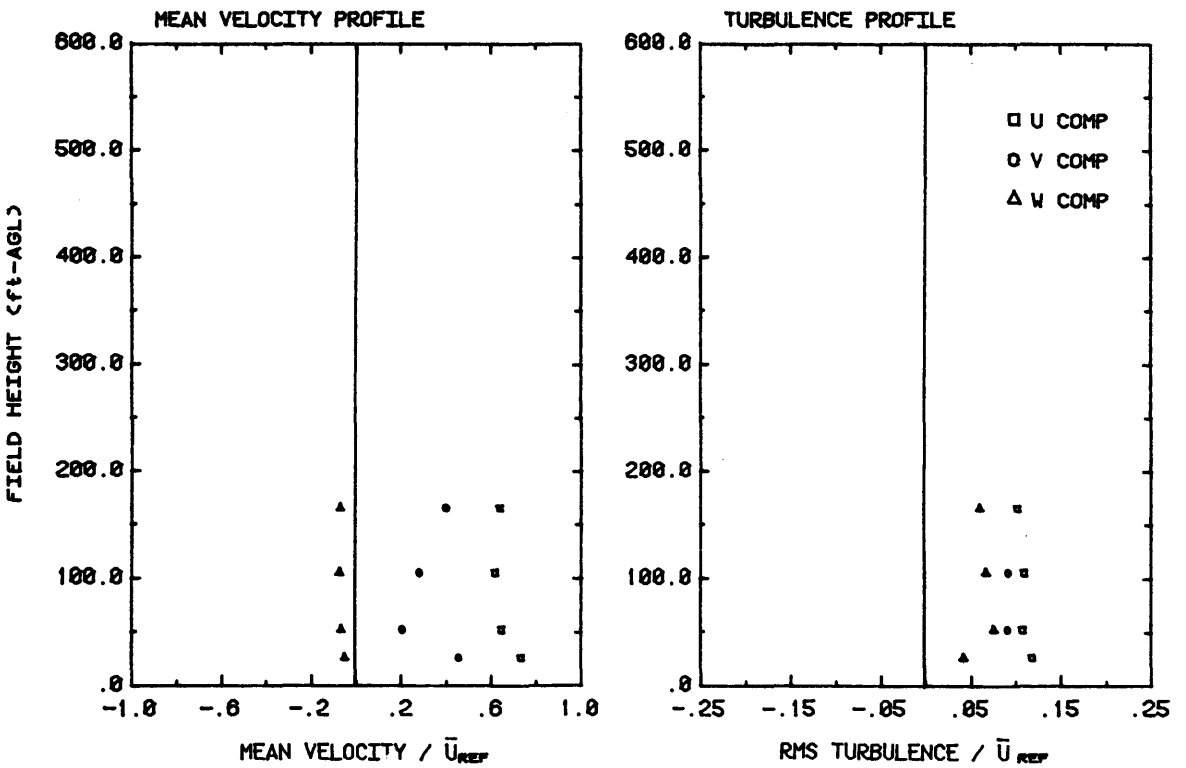


Figure E-4. Normalized mean velocities and turbulence intensity at location B5 for the south (S) wind direction.

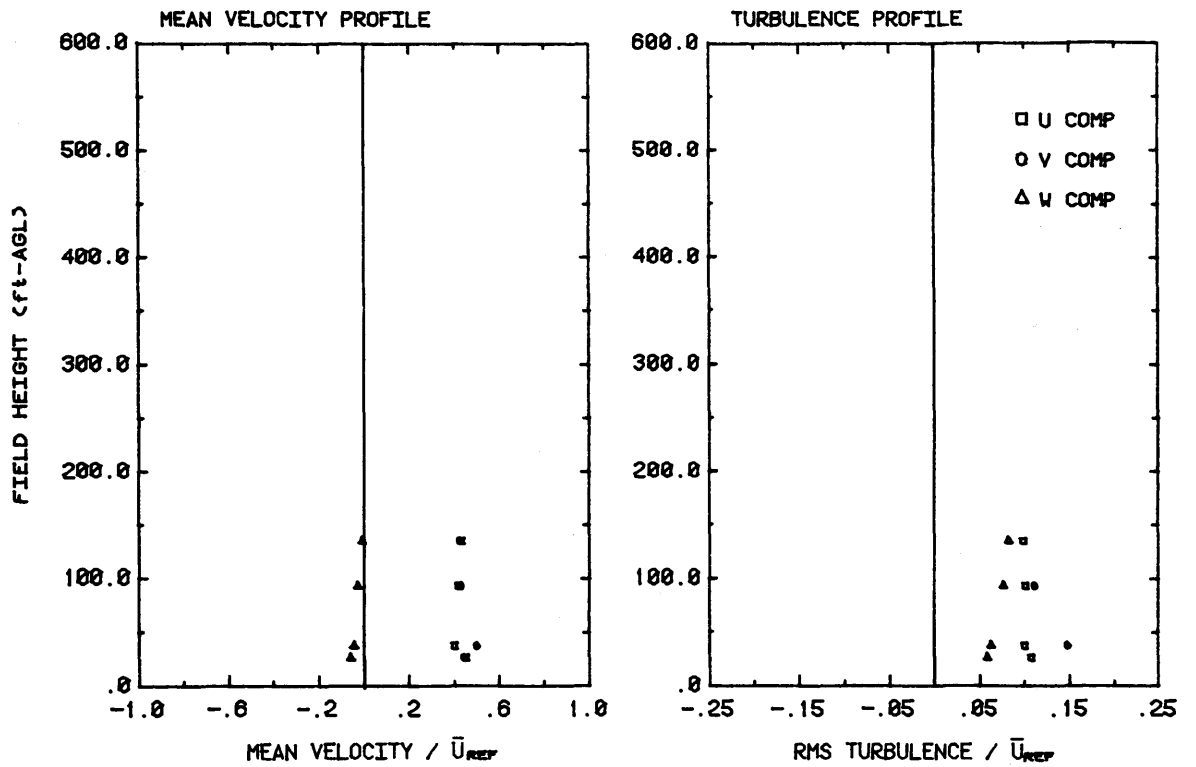


Figure E-5. Normalized mean velocities and turbulence intensity at location C1 for the south (S) wind direction.

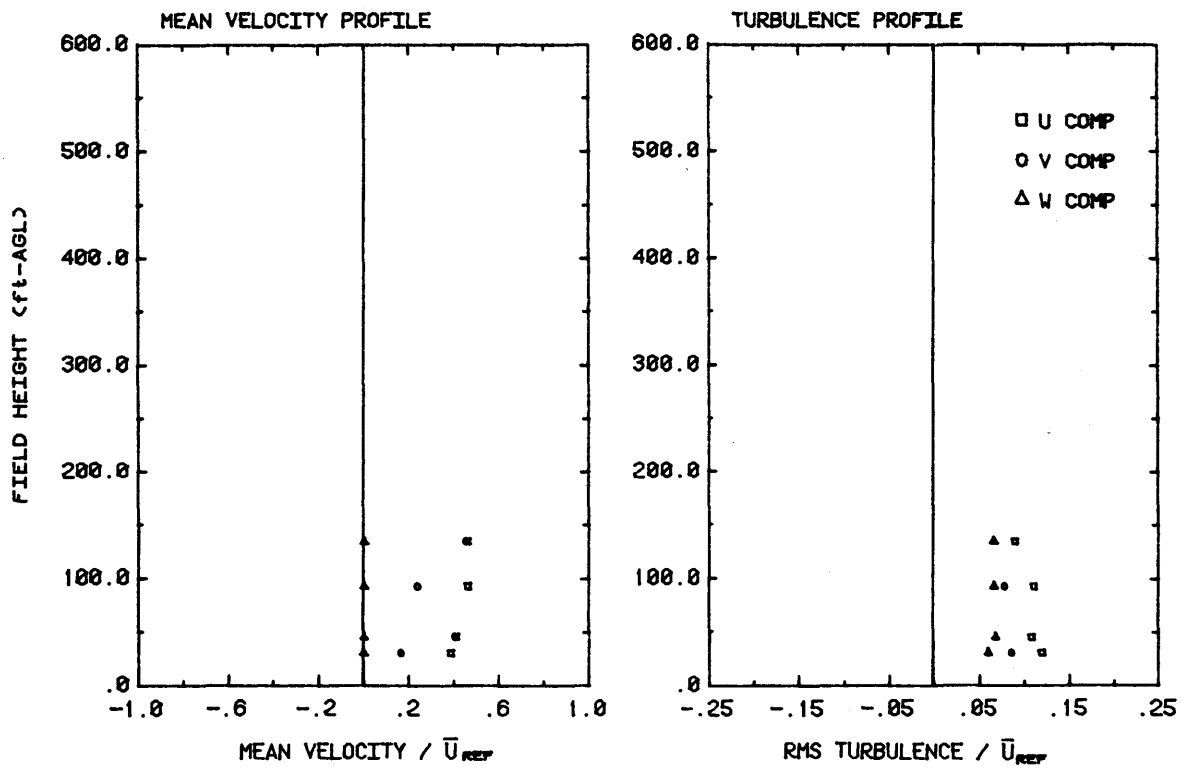


Figure E-6. Normalized mean velocities and turbulence intensity at location C5 for the south (S) wind direction.

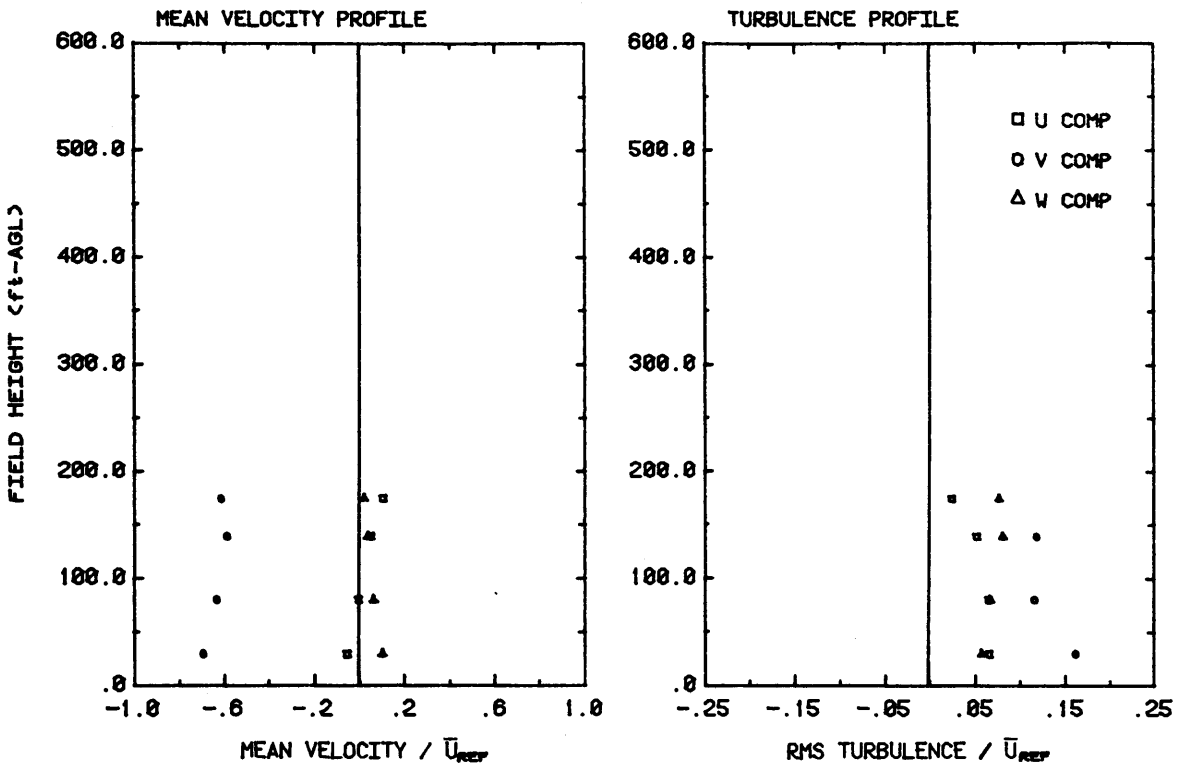


Figure E-7. Normalized mean velocities and turbulence intensity at location F1 for the south (S) wind direction.

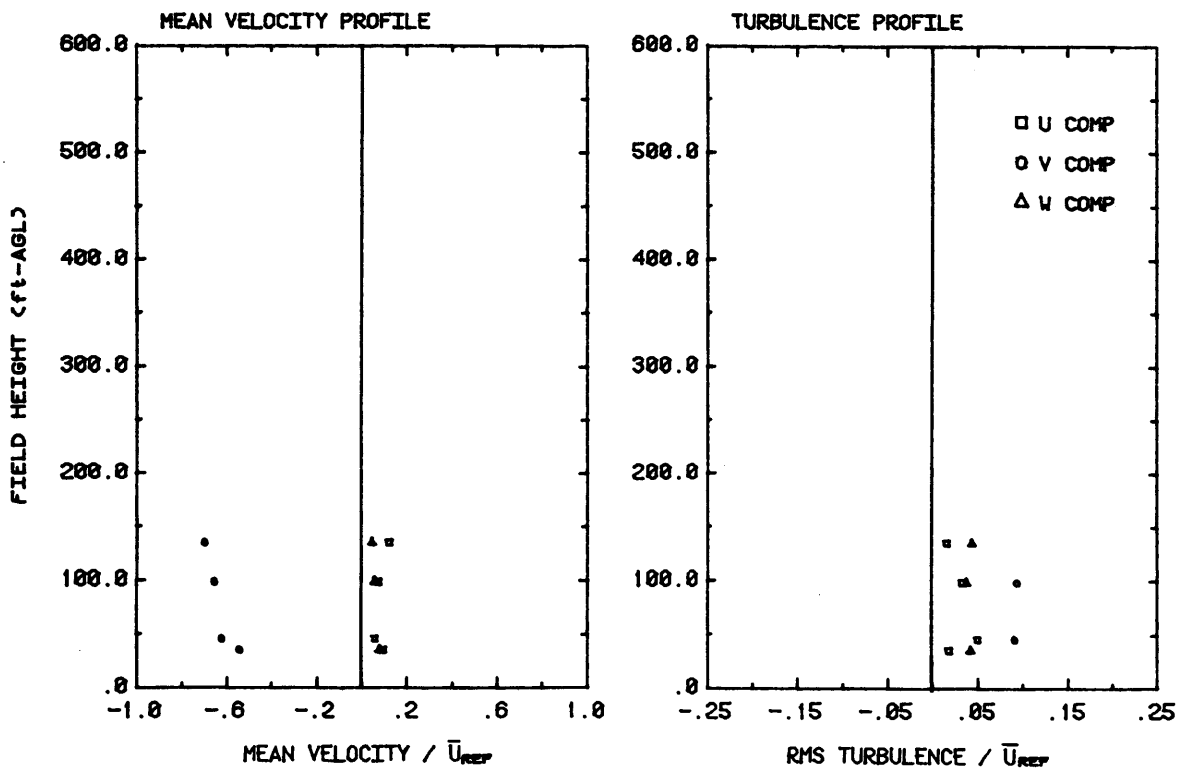


Figure E-8. Normalized mean velocities and turbulence intensity at location F5 for the south (S) wind direction.

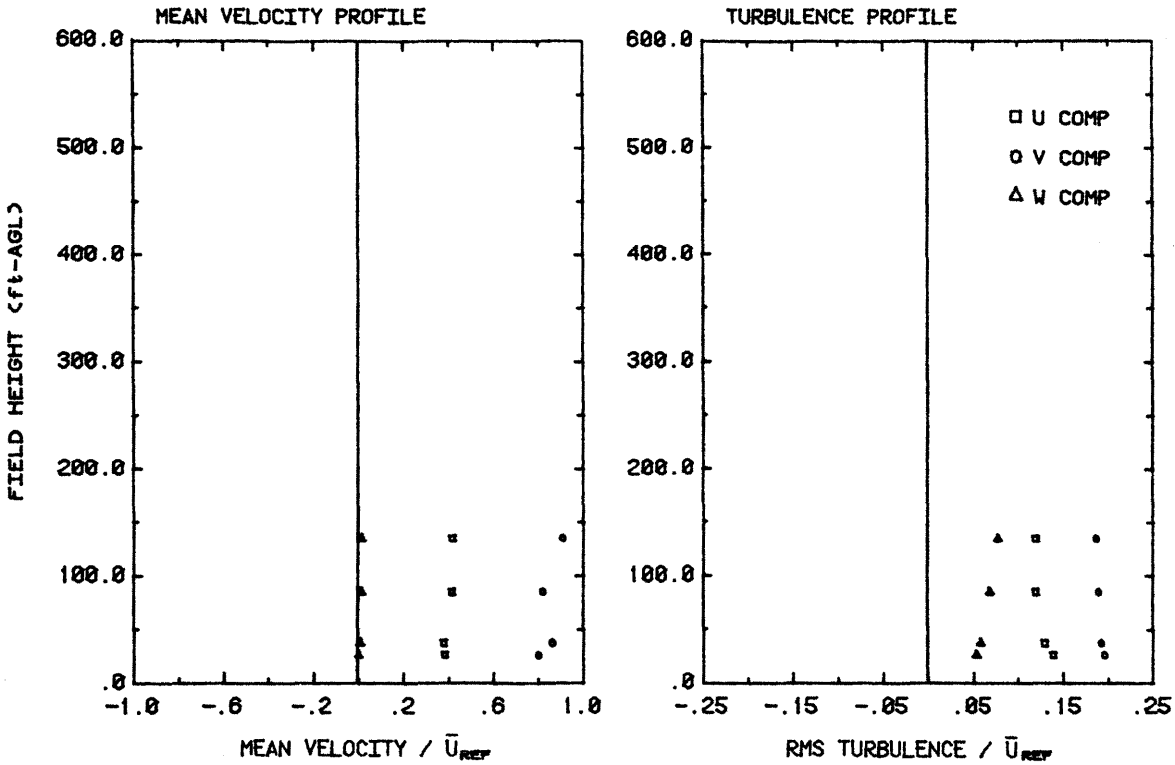


Figure E-9. Normalized mean velocities and turbulence intensity at location G1 for the south (S) wind direction.

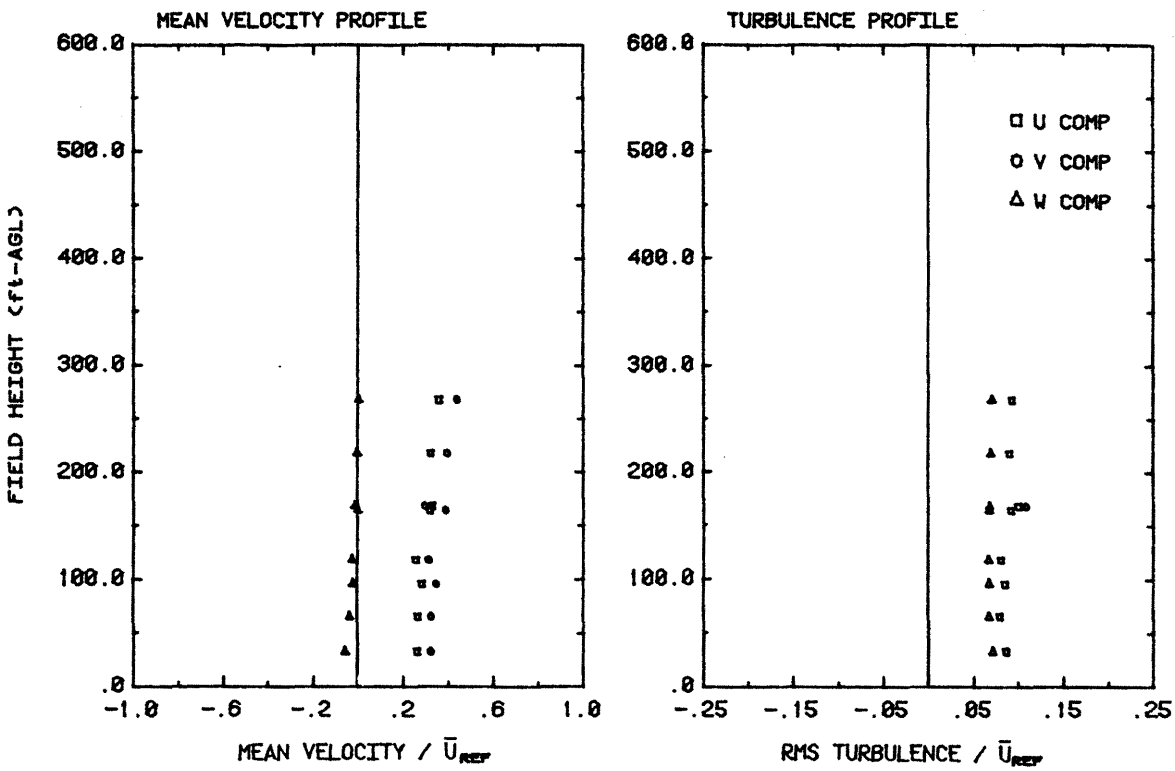


Figure E-10. Normalized mean velocities and turbulence intensity at location G2 for the south (S) wind direction.

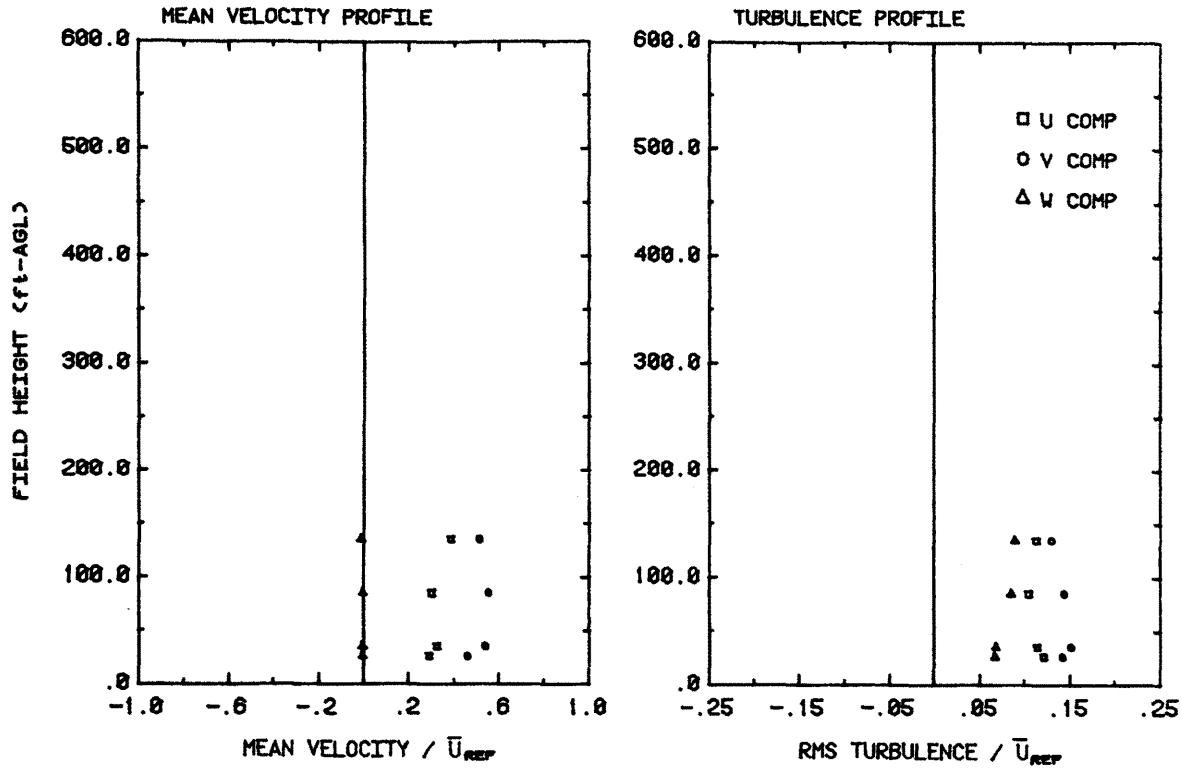


Figure E-11. Normalized mean velocities and turbulence intensity at location G5 for the south (S) wind direction.

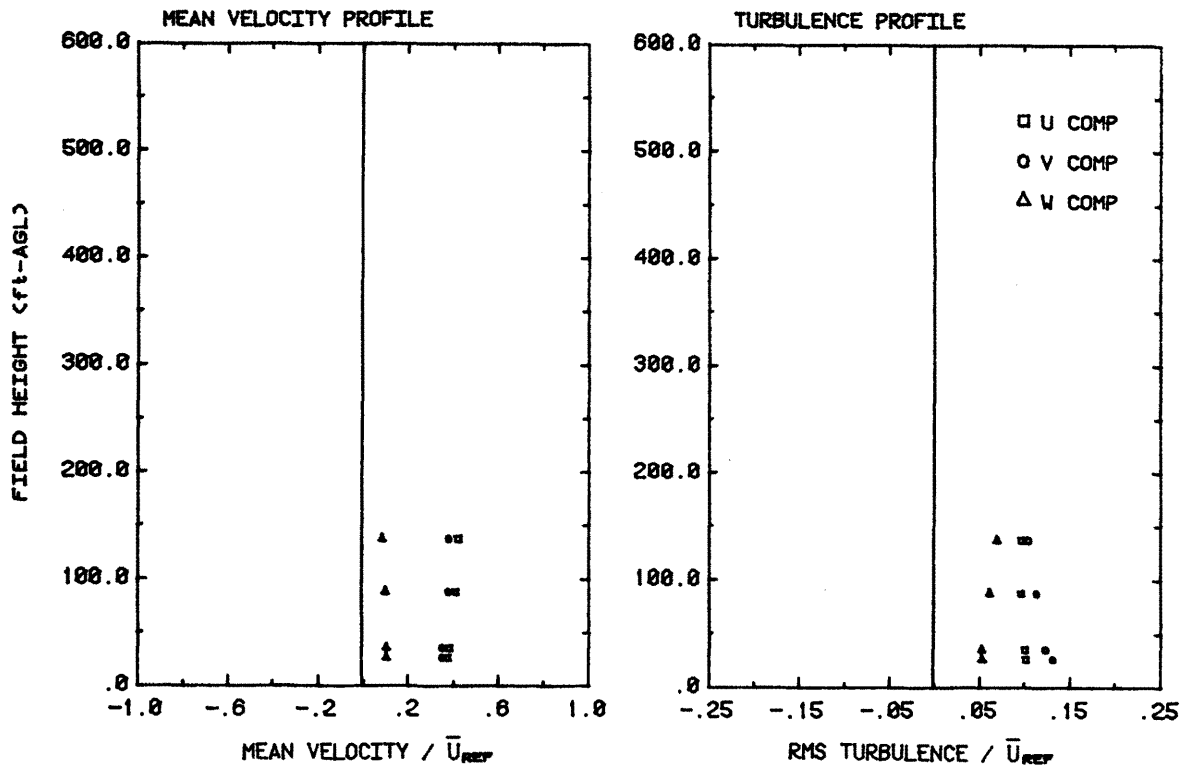


Figure E-12. Normalized mean velocities and turbulence intensity at location H1 for the south (S) wind direction.

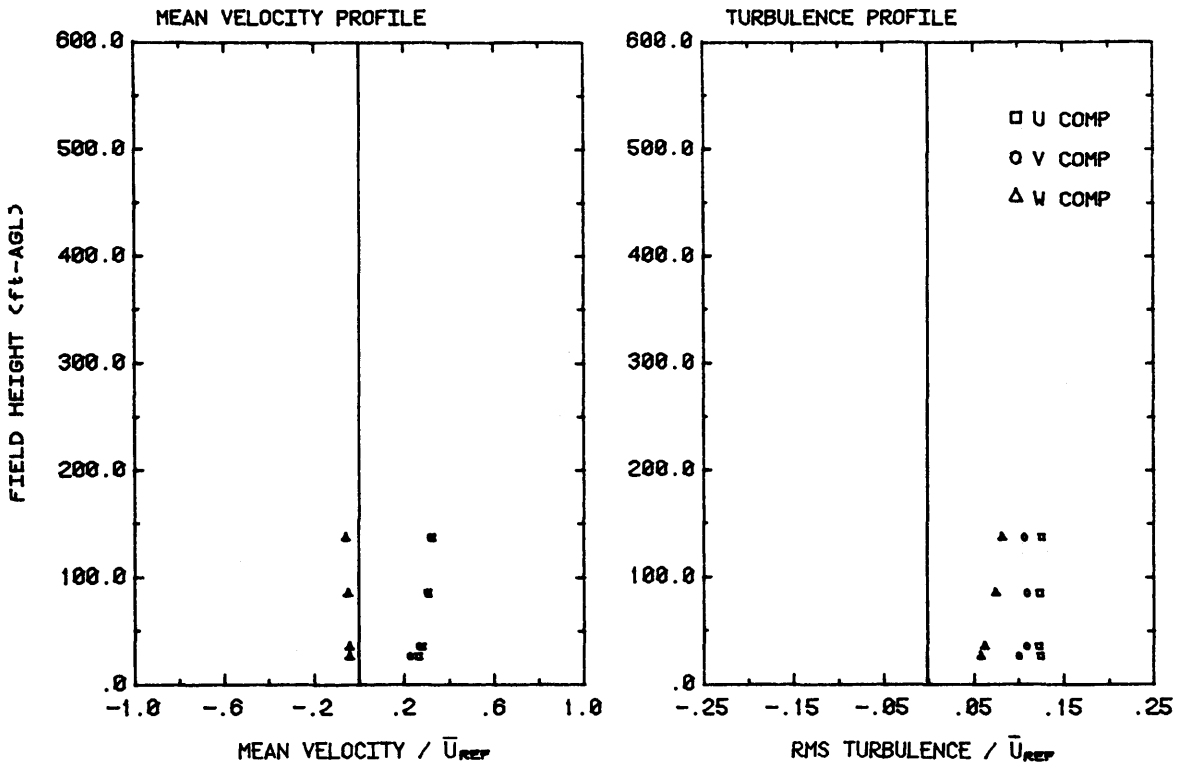


Figure E-13. Normalized mean velocities and turbulence intensity at location H5 for the south (S) wind direction.

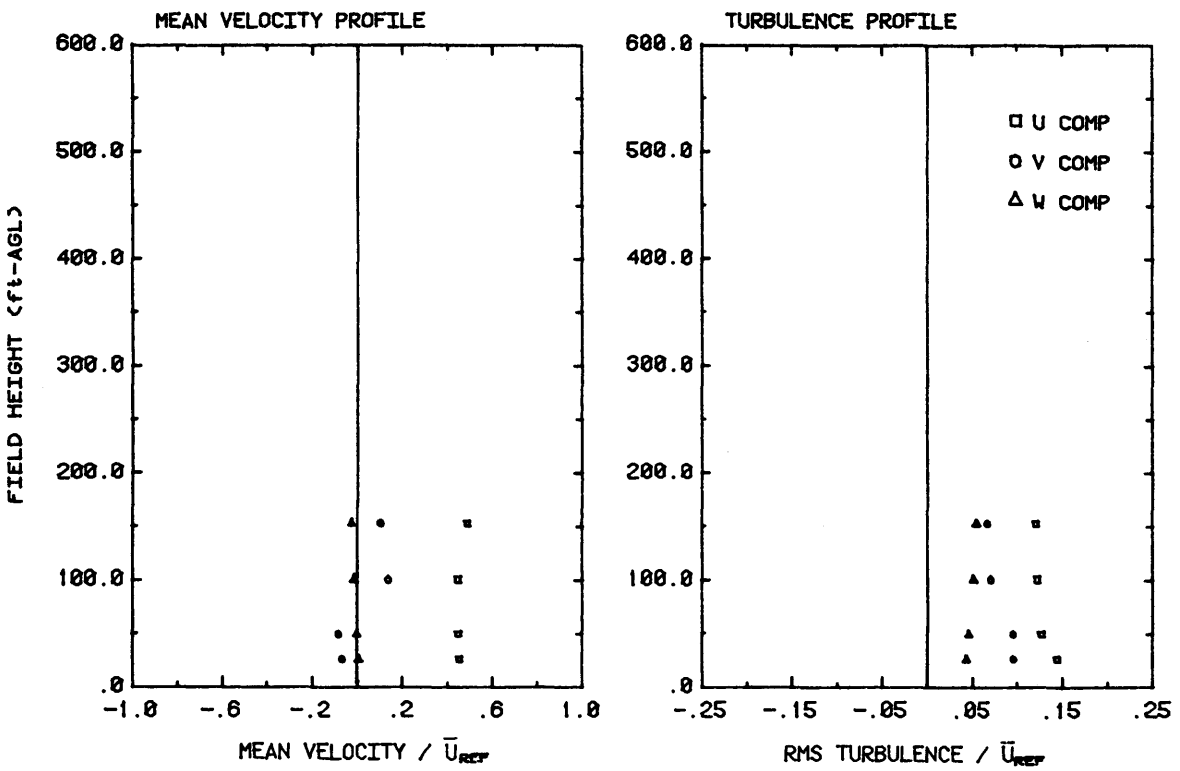


Figure E-14. Normalized mean velocities and turbulence intensity at location I1 for the south (S) wind direction.

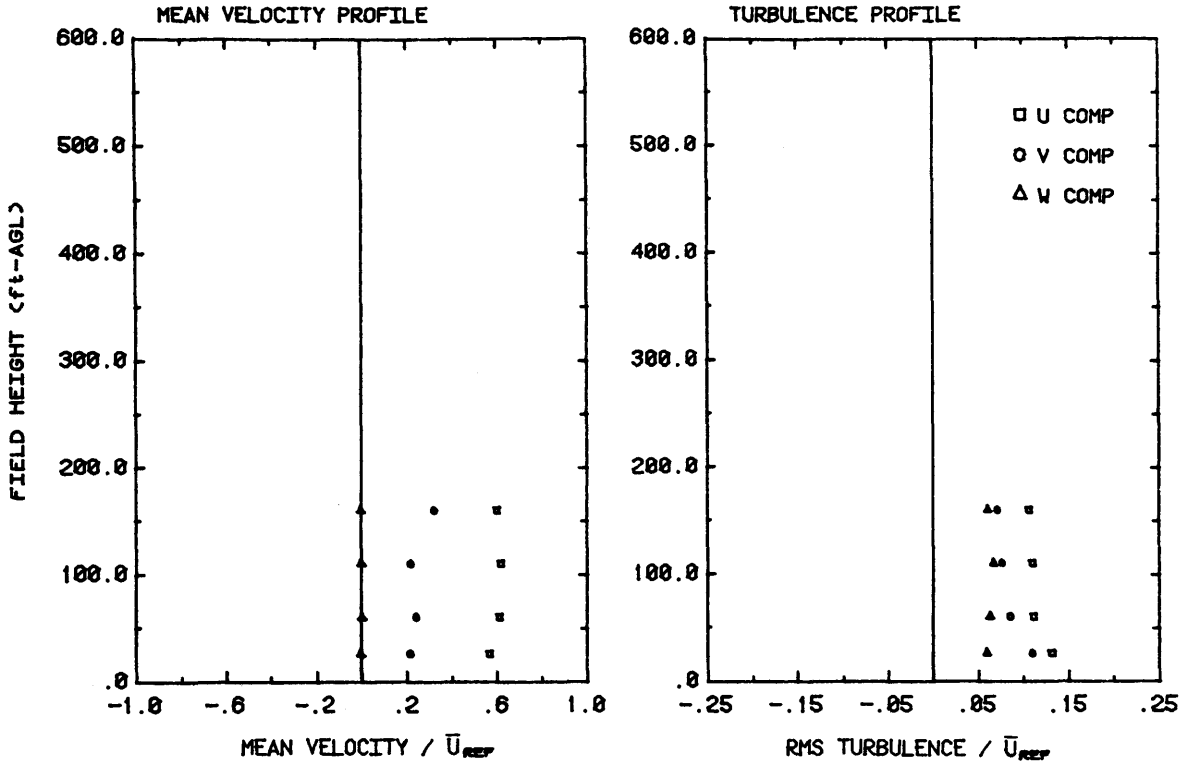


Figure E-15. Normalized mean velocities and turbulence intensity at location I5 for the south (S) wind direction.

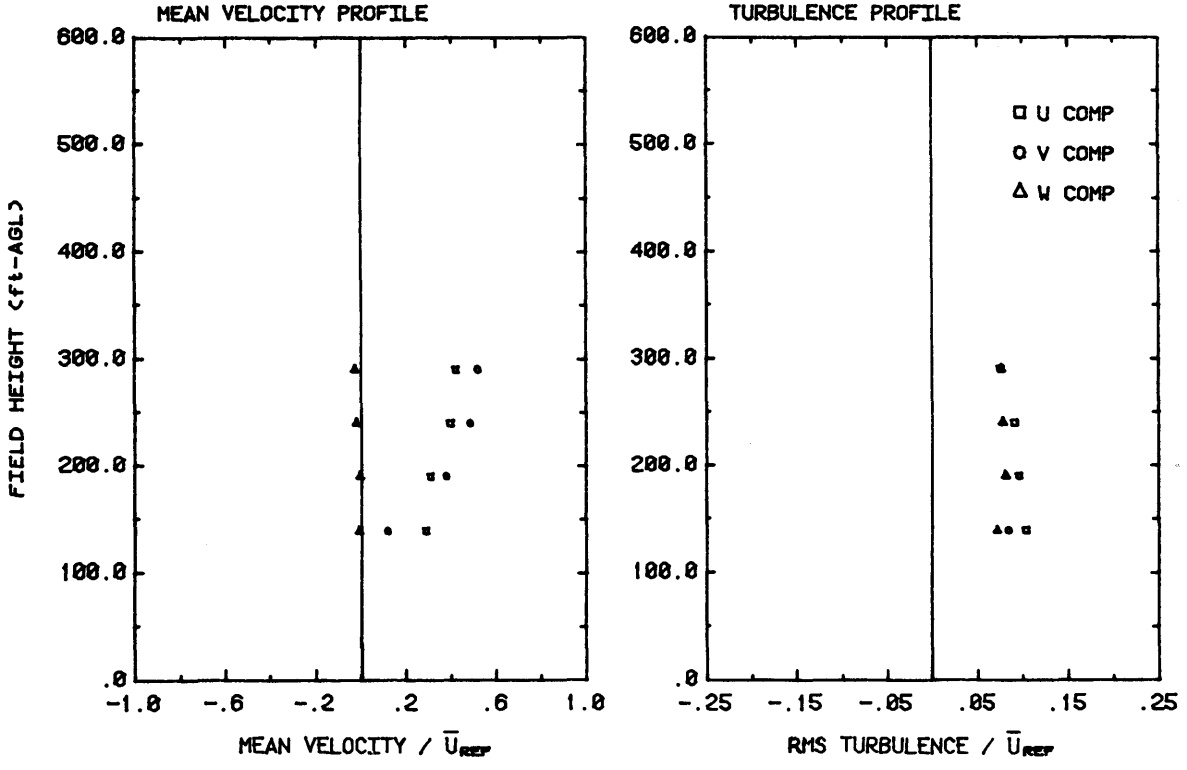


Figure E-16. Normalized mean velocities and turbulence intensity at location J4 for the south (S) wind direction.

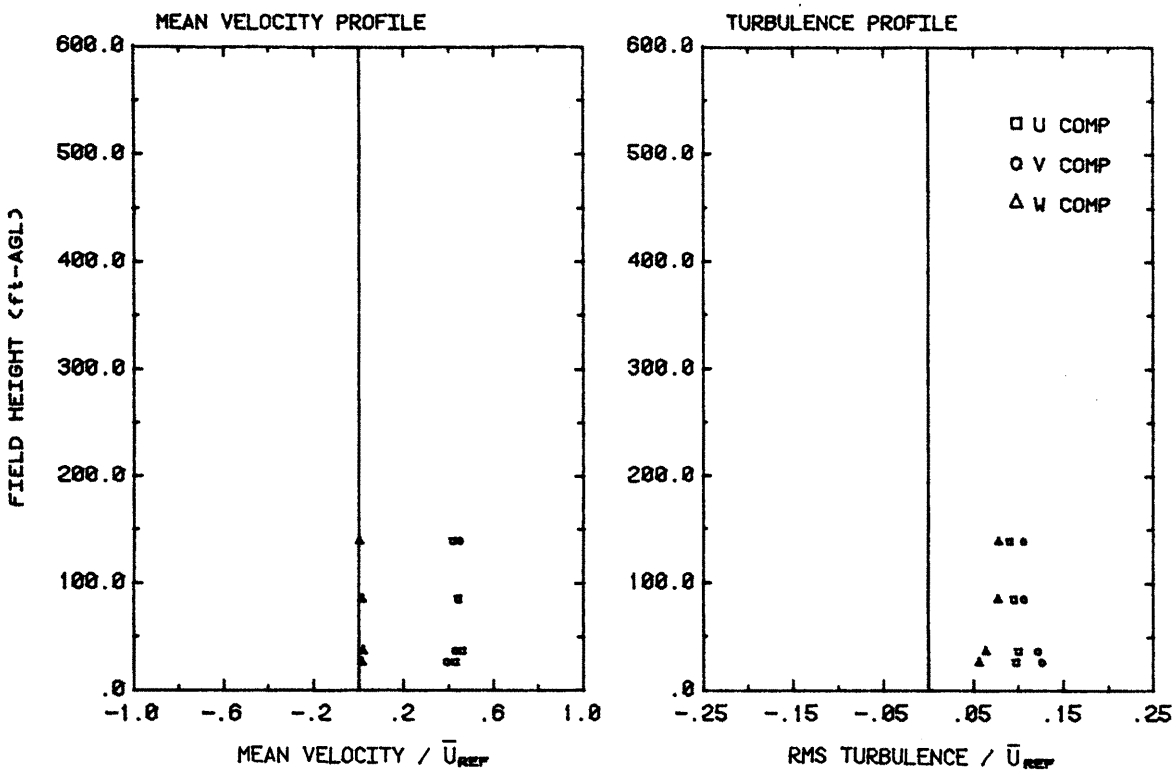


Figure E-17. Normalized mean velocities and turbulence intensity at location J5 for the south (S) wind direction.

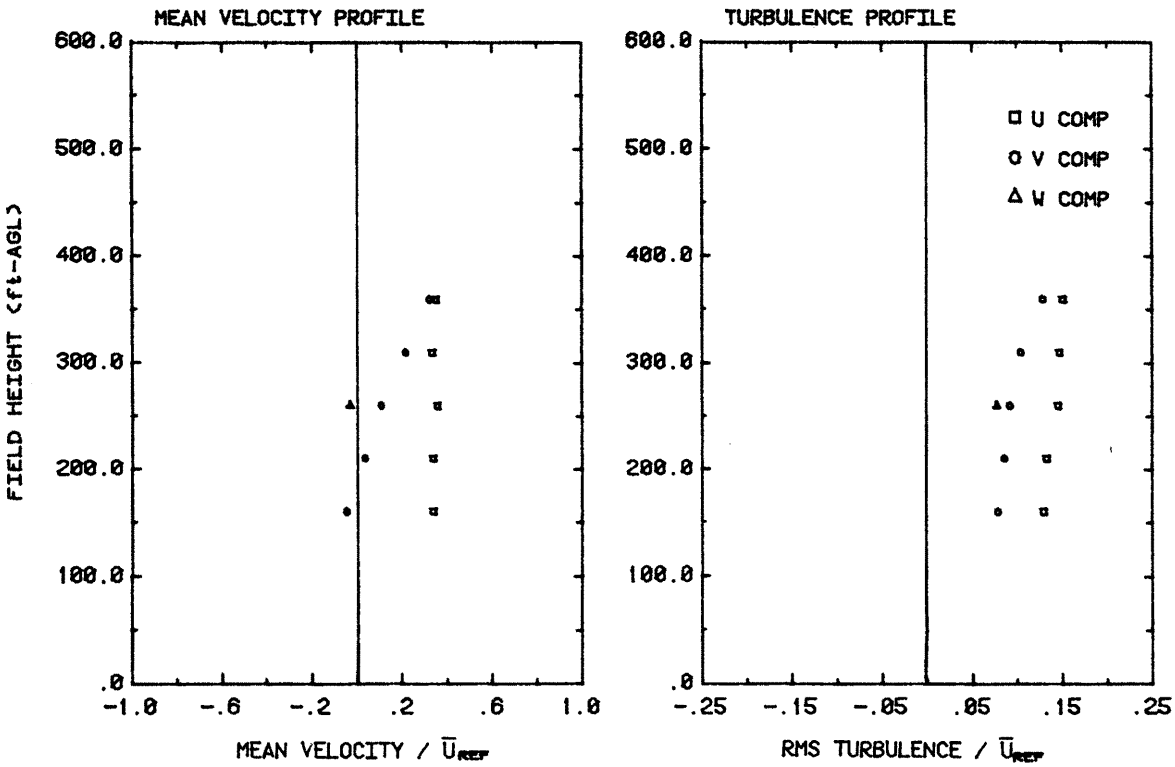


Figure E-18. Normalized mean velocities and turbulence intensity at location K2 for the south (S) wind direction.

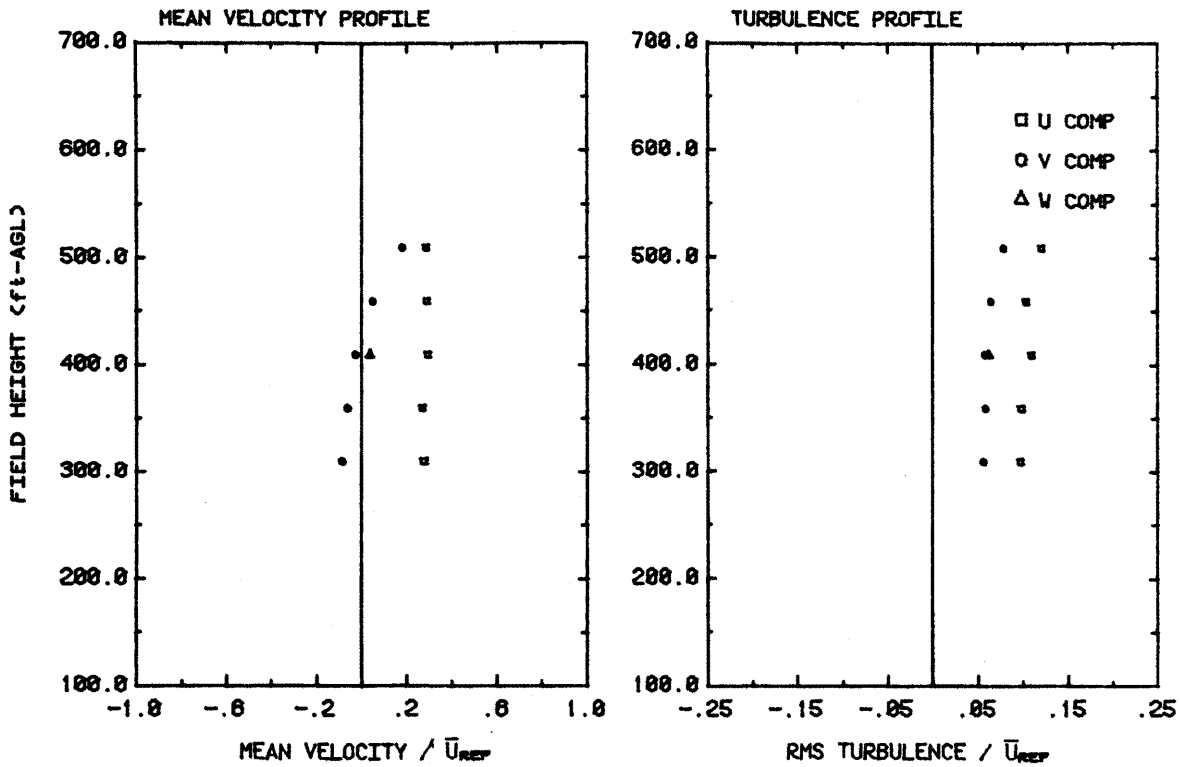


Figure E-19. Normalized mean velocities and turbulence intensity at location K3 for the south (S) wind direction.

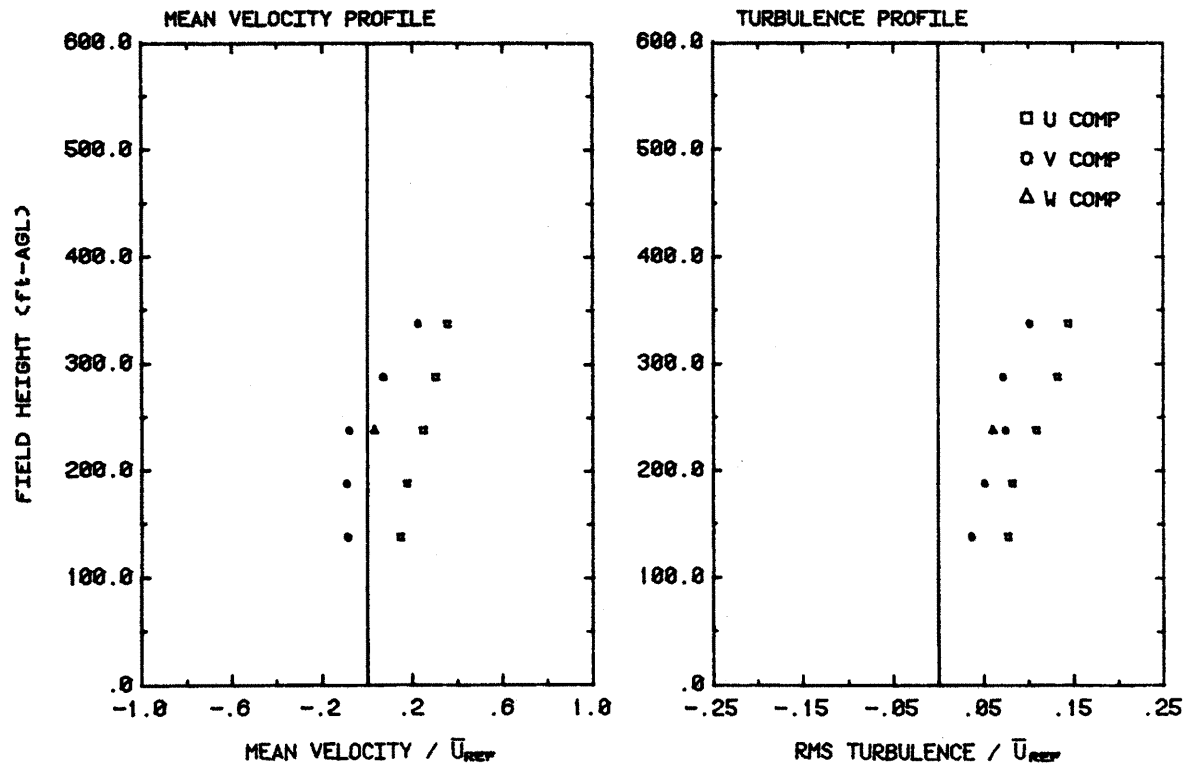


Figure E-20. Normalized mean velocities and turbulence intensity at location K4 for the south (S) wind direction.

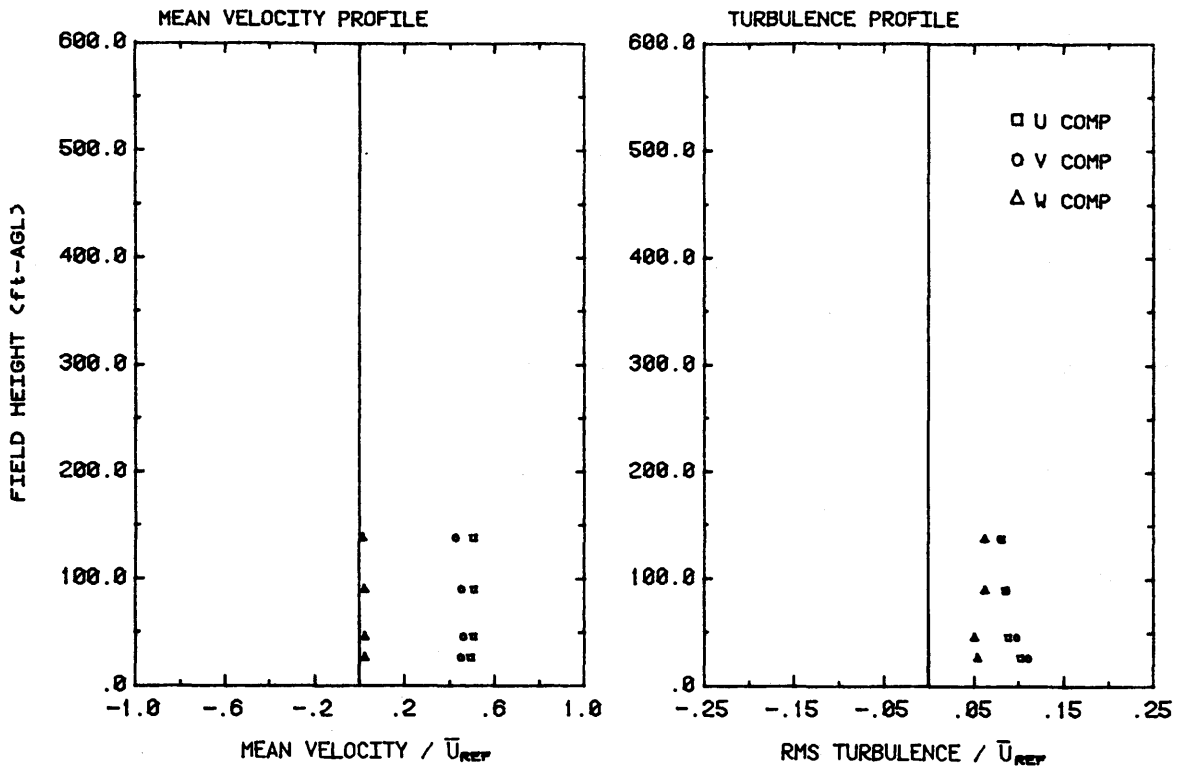


Figure E-21. Normalized mean velocities and turbulence intensity at location K5 for the south (S) wind direction.

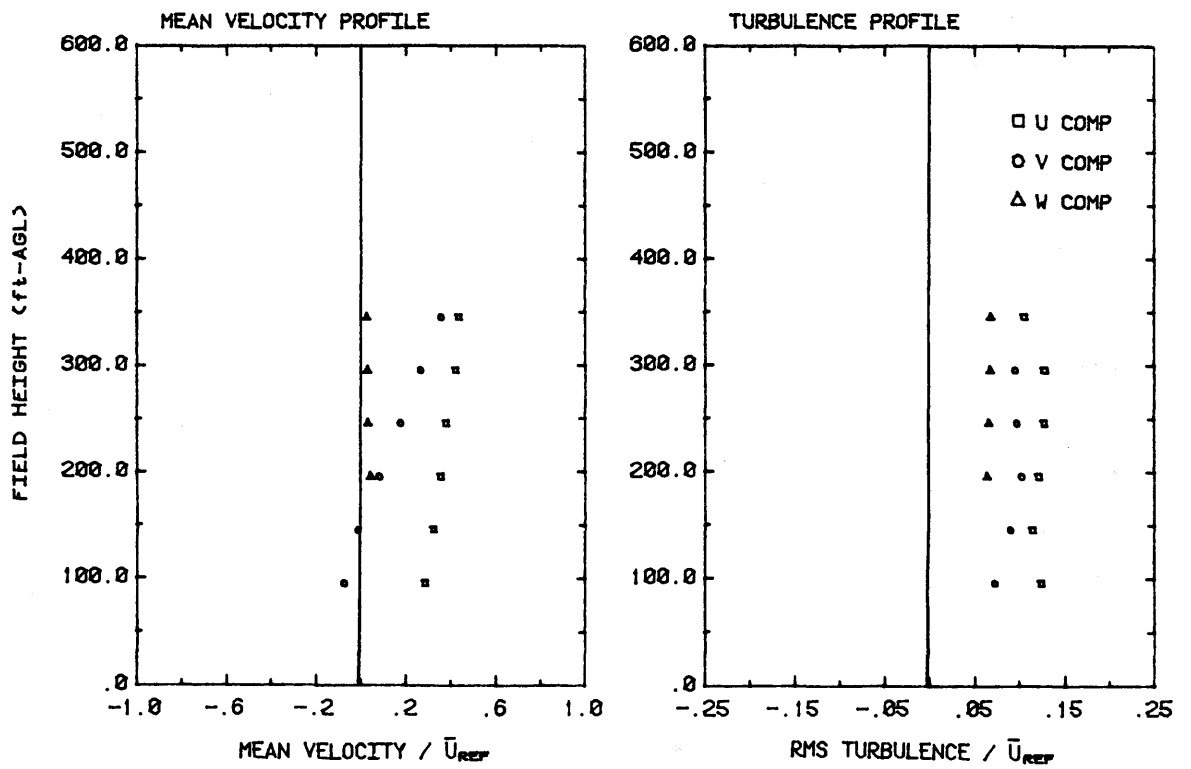


Figure E-22. Normalized mean velocities and turbulence intensity at location L2 for the south (S) wind direction.

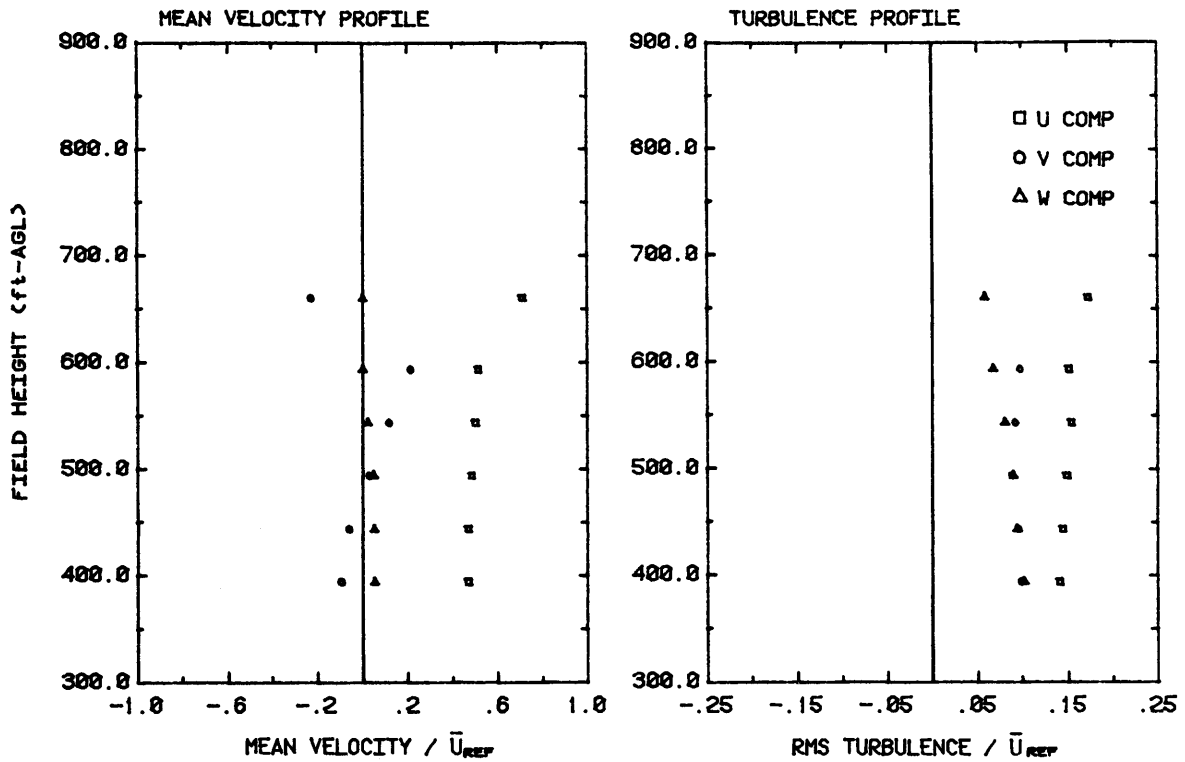


Figure E-23. Normalized mean velocities and turbulence intensity at location L3 for the south (S) wind direction.

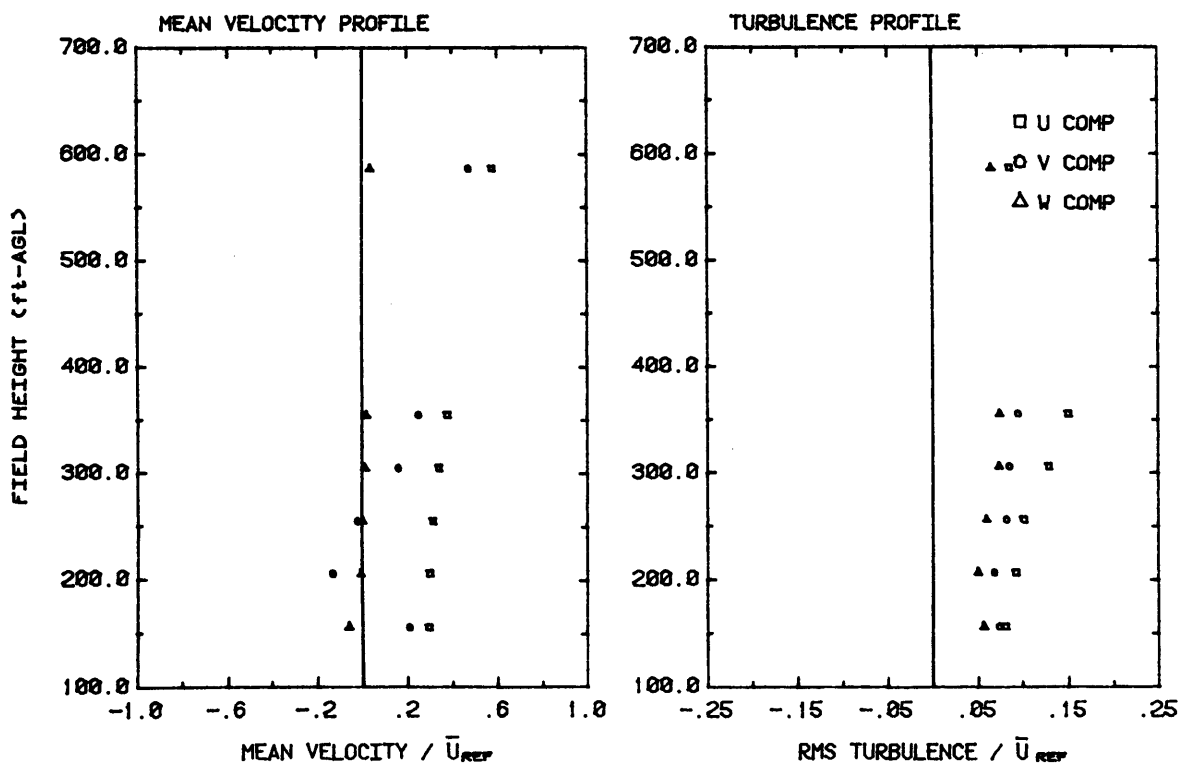


Figure E-24. Normalized mean velocities and turbulence intensity at location L4 for the south (S) wind direction.

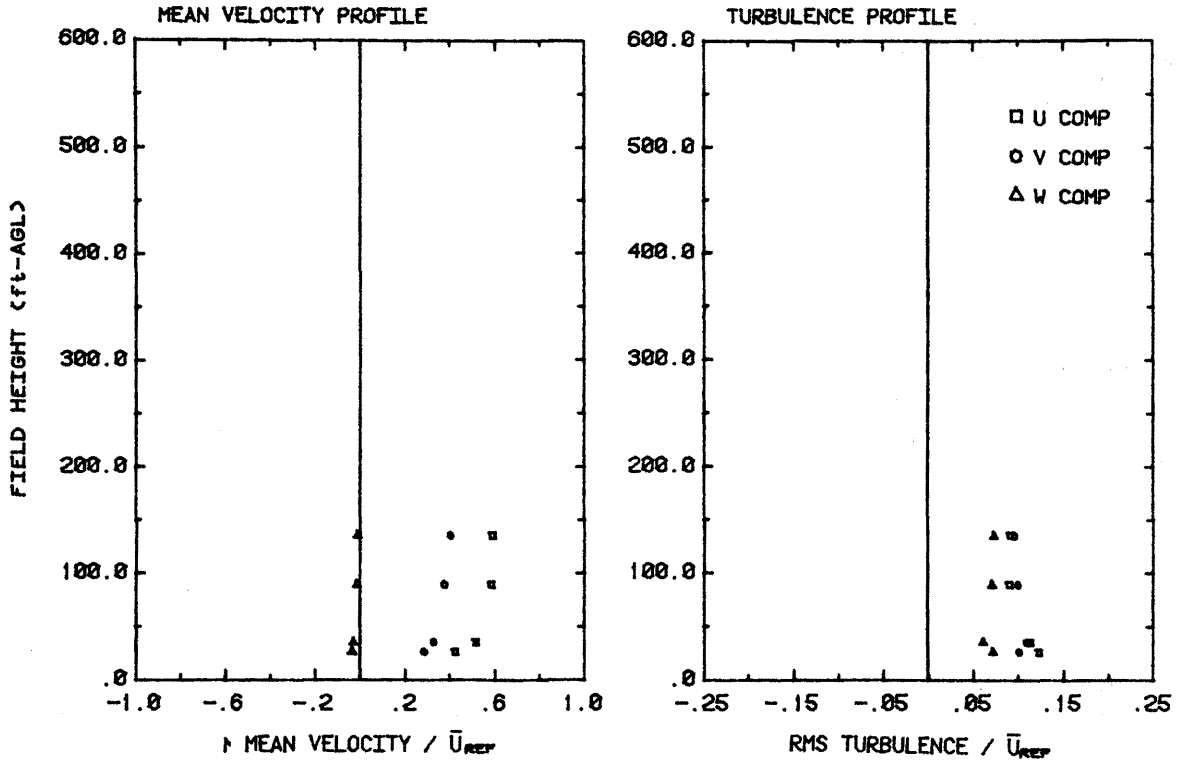


Figure E-25. Normalized mean velocities and turbulence intensity at location L5 for the south (S) wind direction.

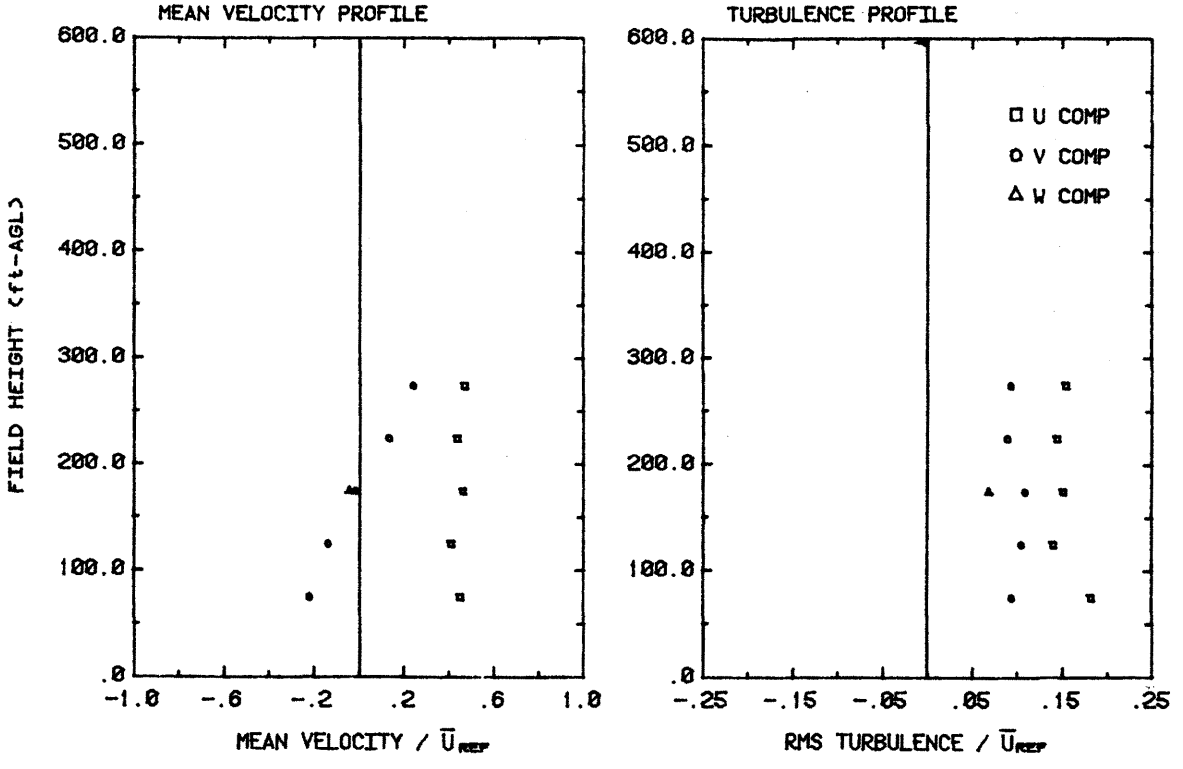


Figure E-26. Normalized mean velocities and turbulence intensity at location M2 for the south (S) wind direction.

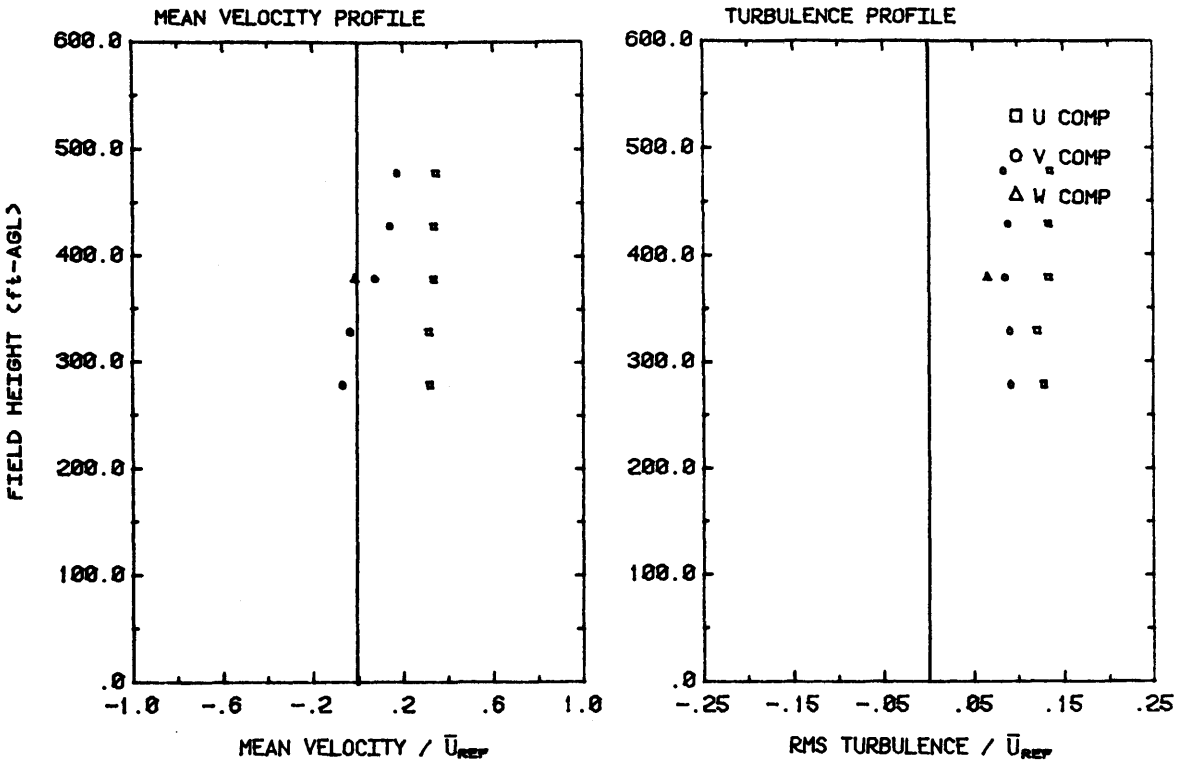


Figure E-27. Normalized mean velocities and turbulence intensity at location M3 for the south (S) wind direction.

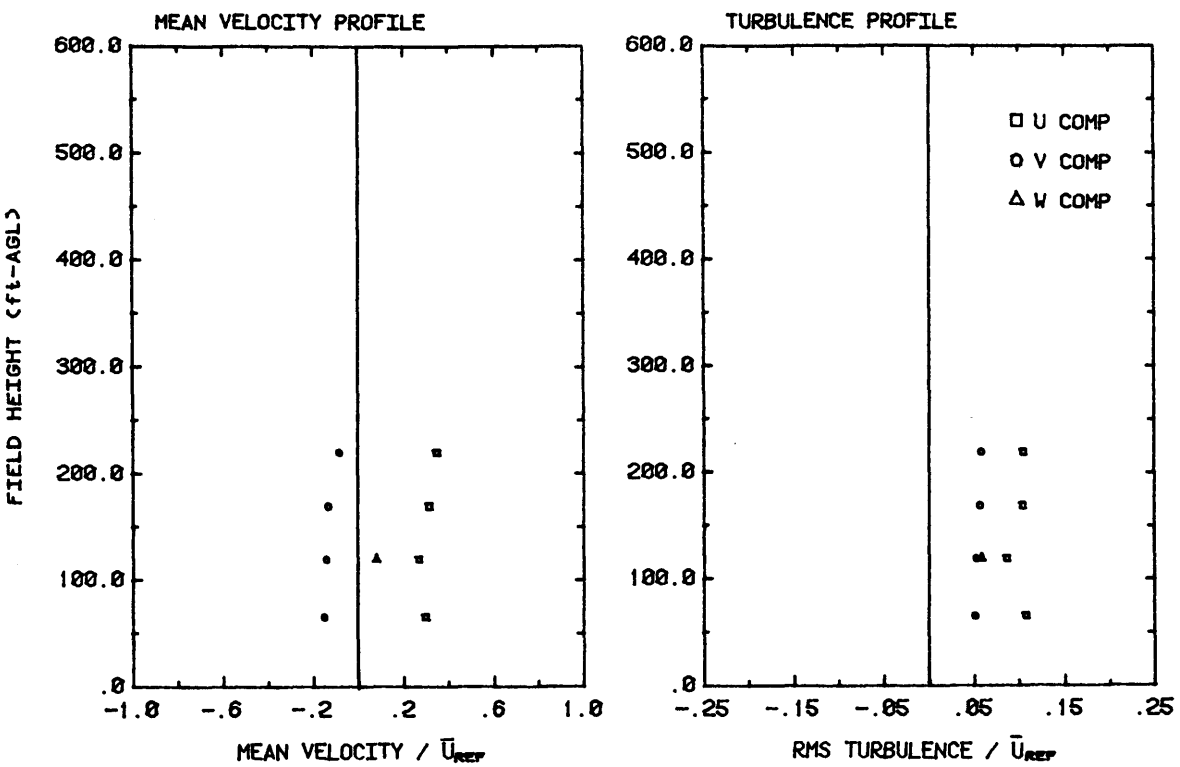


Figure E-28. Normalized mean velocities and turbulence intensity at location M4 for the south (S) wind direction.

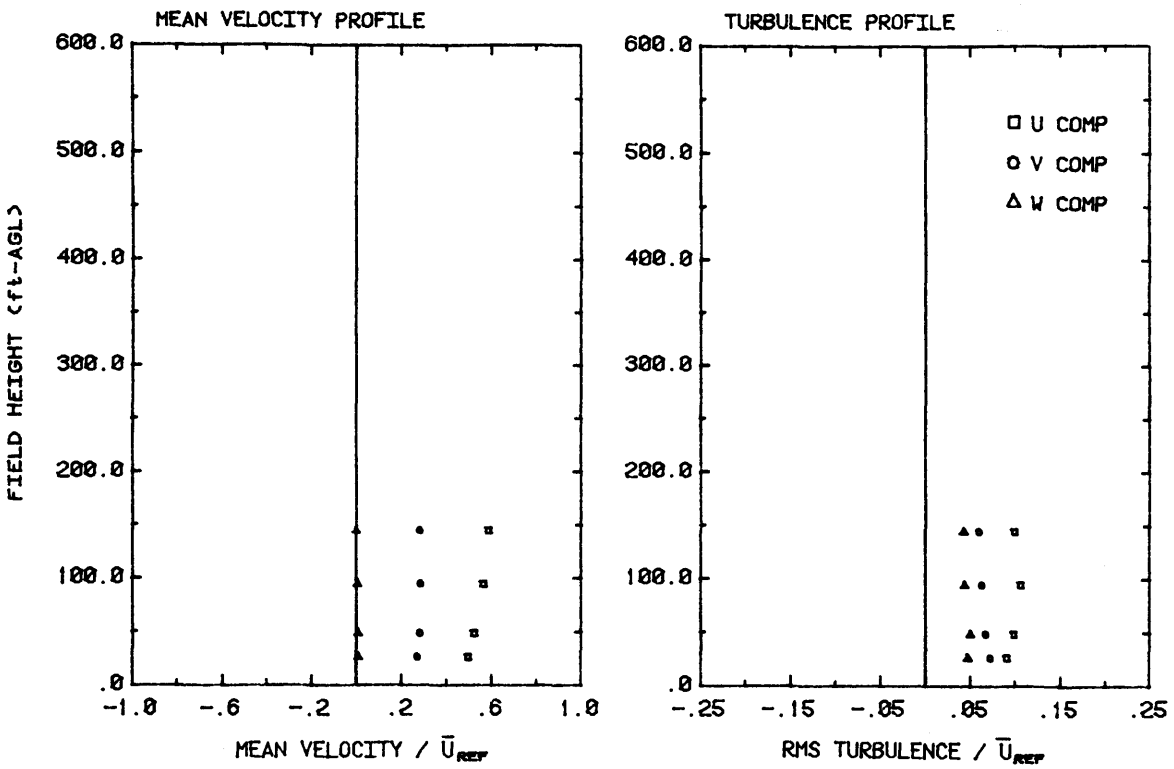


Figure E-29. Normalized mean velocities and turbulence intensity at location M5 for the south (S) wind direction.

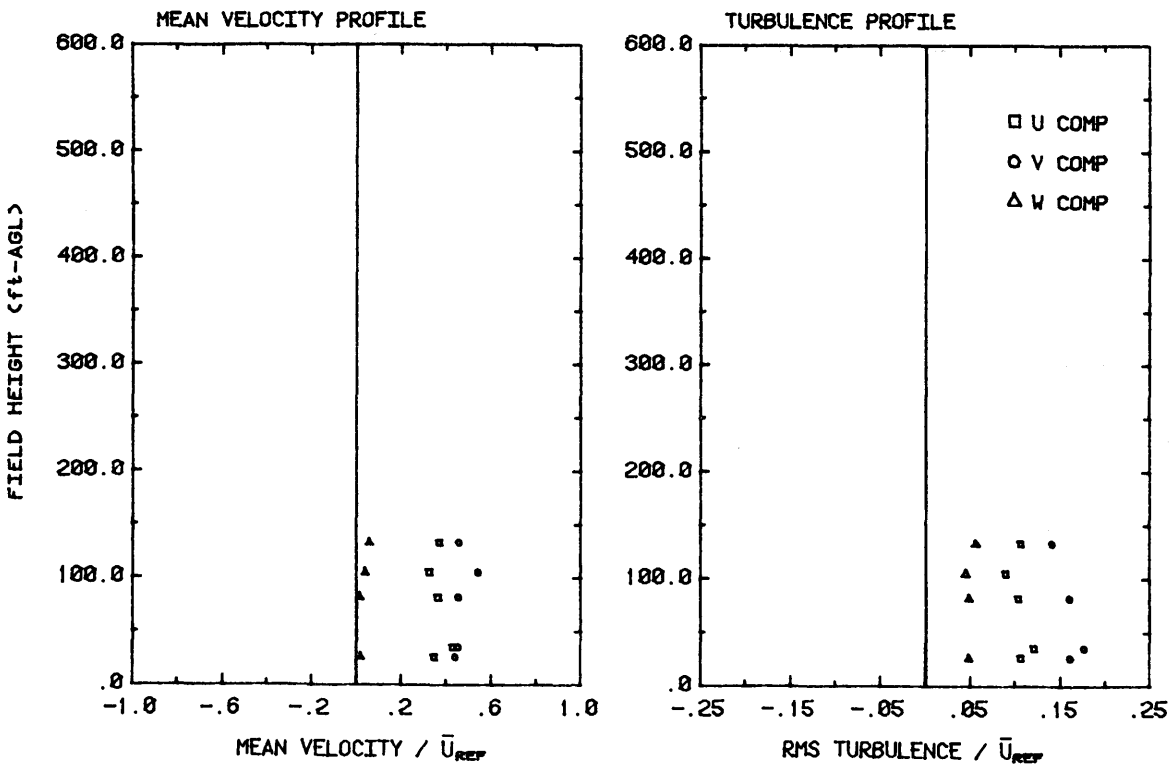


Figure E-30. Normalized mean velocities and turbulence intensity at location N1 for the south (S) wind direction.

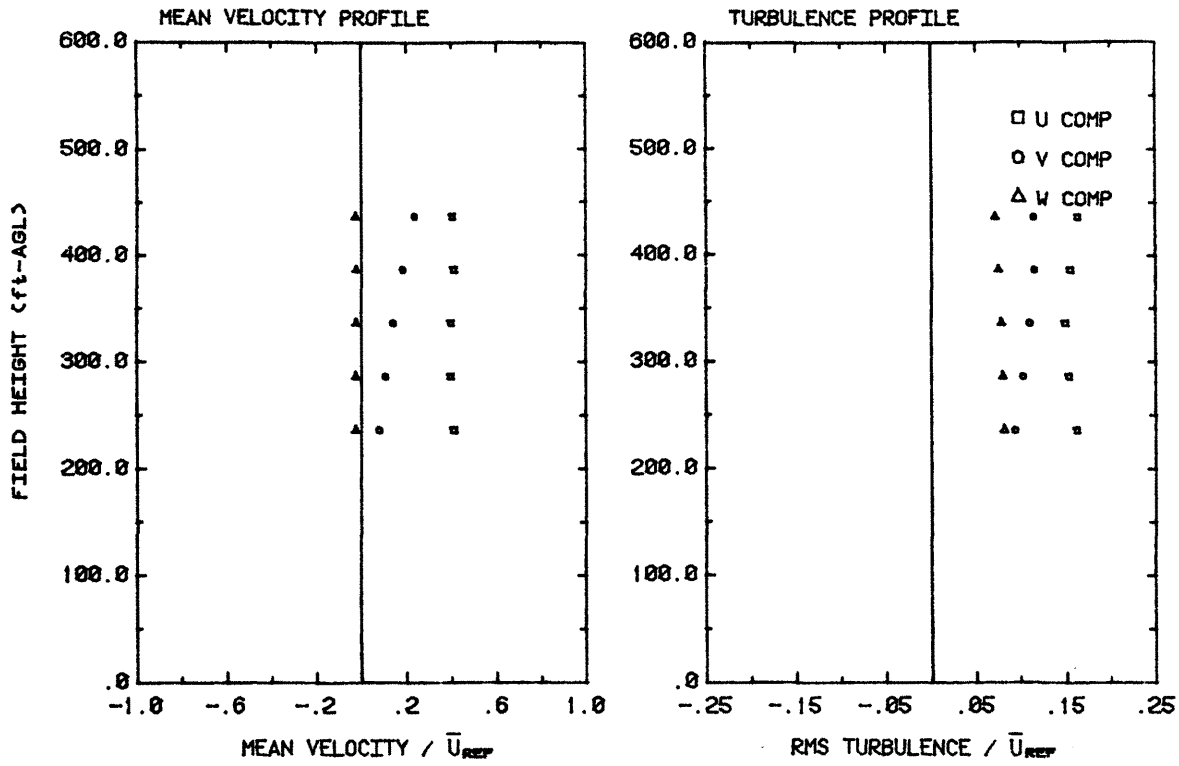


Figure E-31. Normalized mean velocities and turbulence intensity at location N2 for the south (S) wind direction.

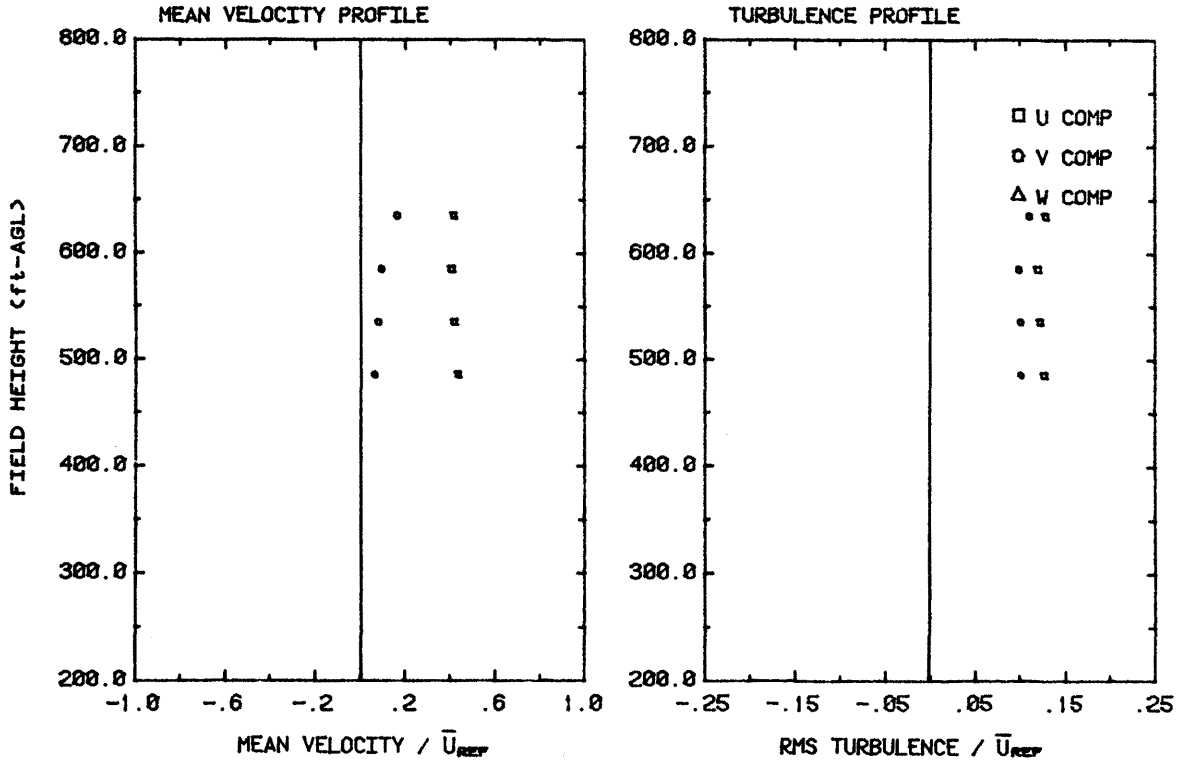


Figure E-32. Normalized mean velocities and turbulence intensity at location N3 for the south (S) wind direction.

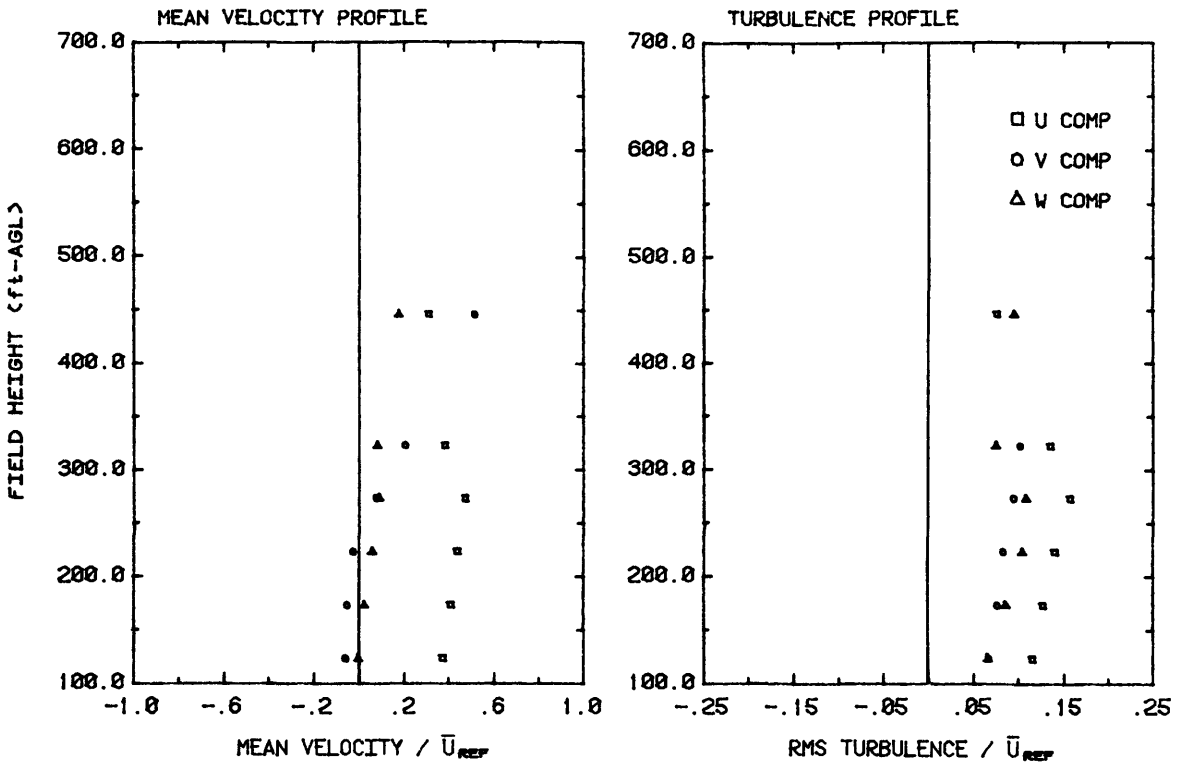


Figure E-33. Normalized mean velocities and turbulence intensity at location N4 for the south (S) wind direction.

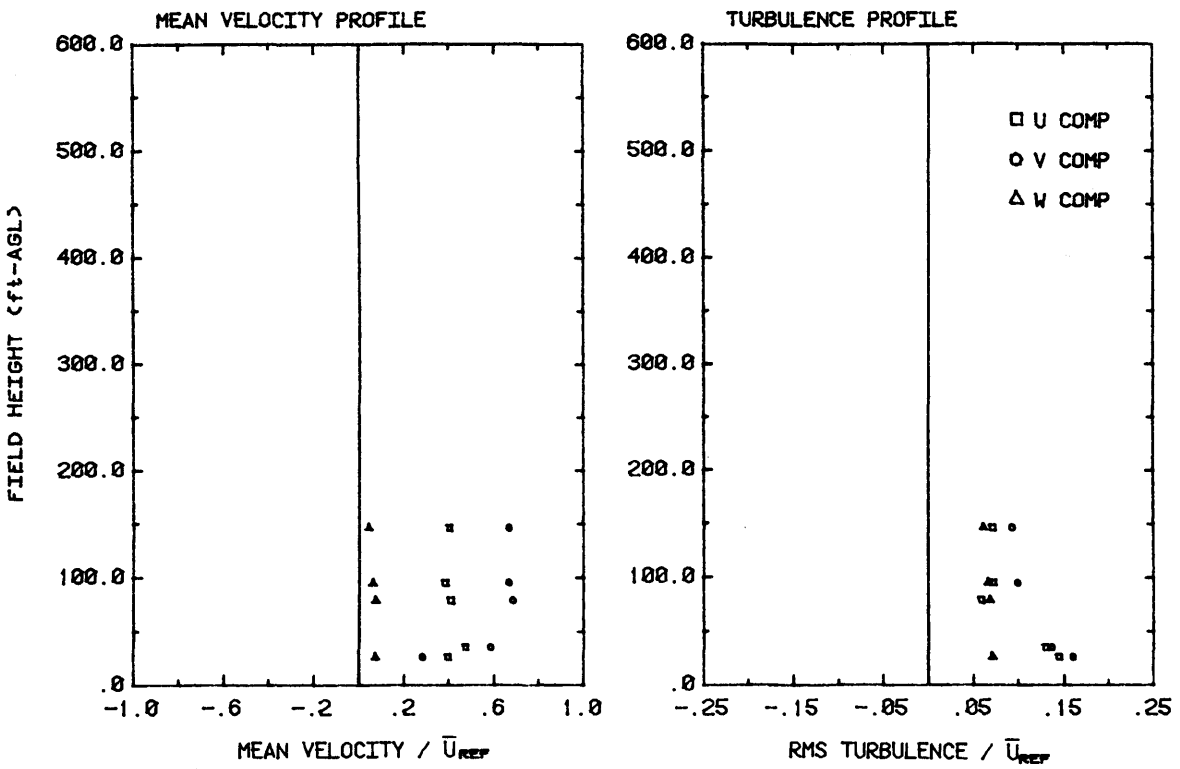


Figure E-34. Normalized mean velocities and turbulence intensity at location N5 for the south (S) wind direction.

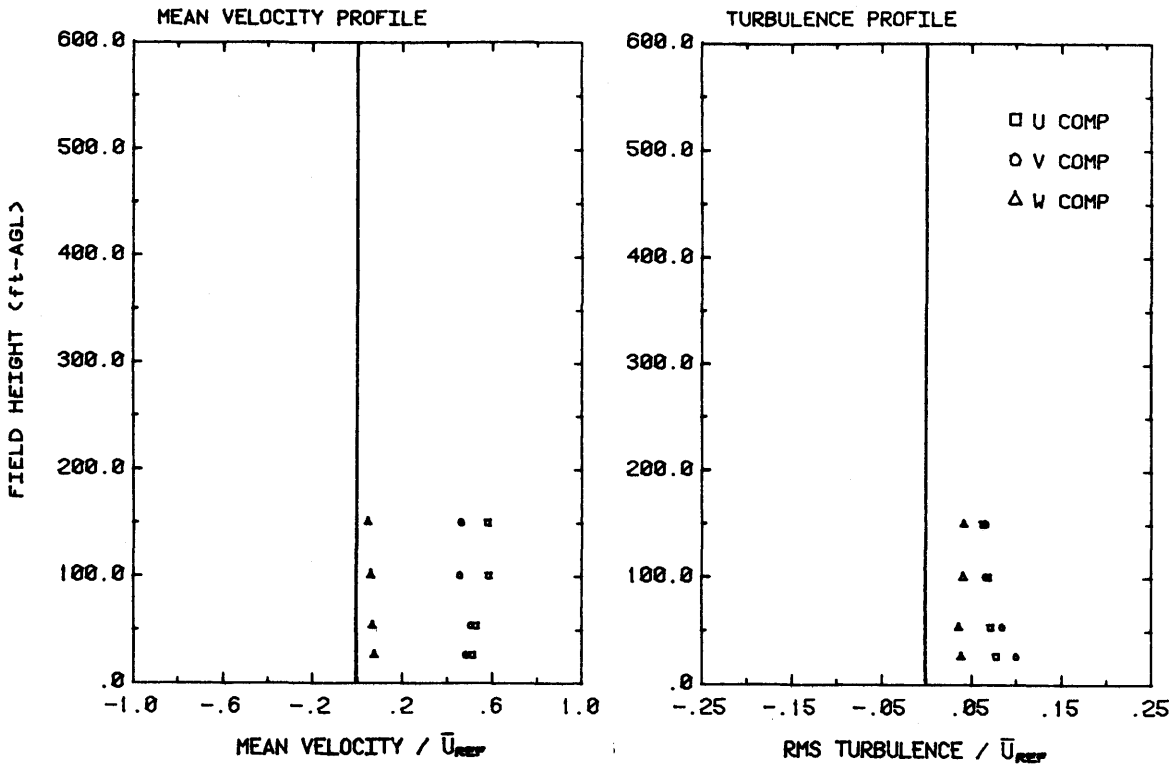


Figure E-35. Normalized mean velocities and turbulence intensity at location 01 for the south (S) wind direction.

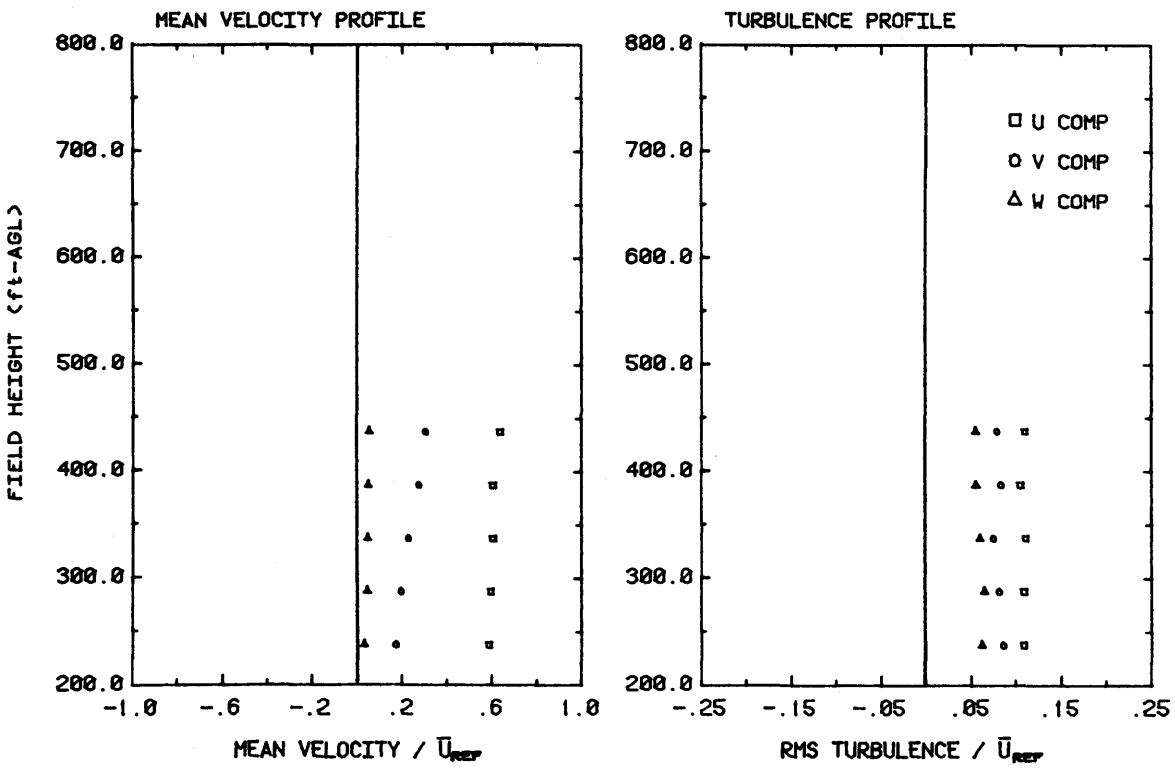


Figure E-36. Normalized mean velocities and turbulence intensity at location 02 for the south (S) wind direction.

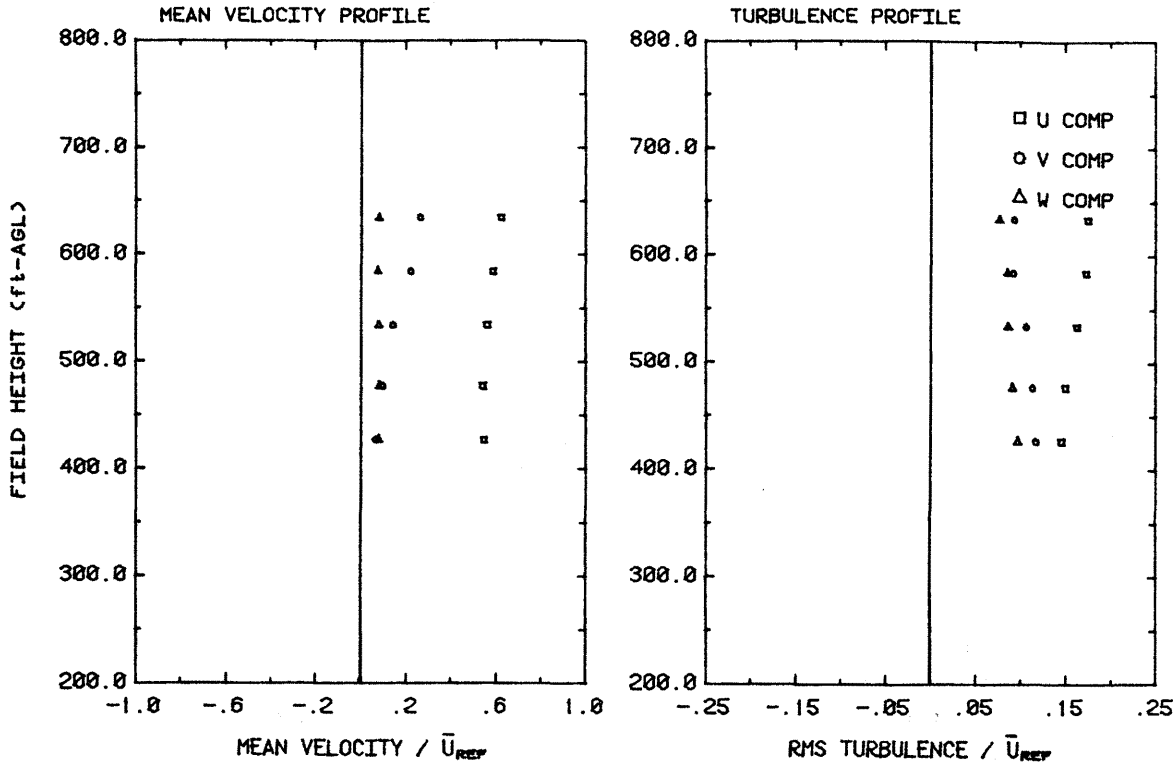


Figure E-37. Normalized mean velocities and turbulence intensity at location 03 for the south (S) wind direction.

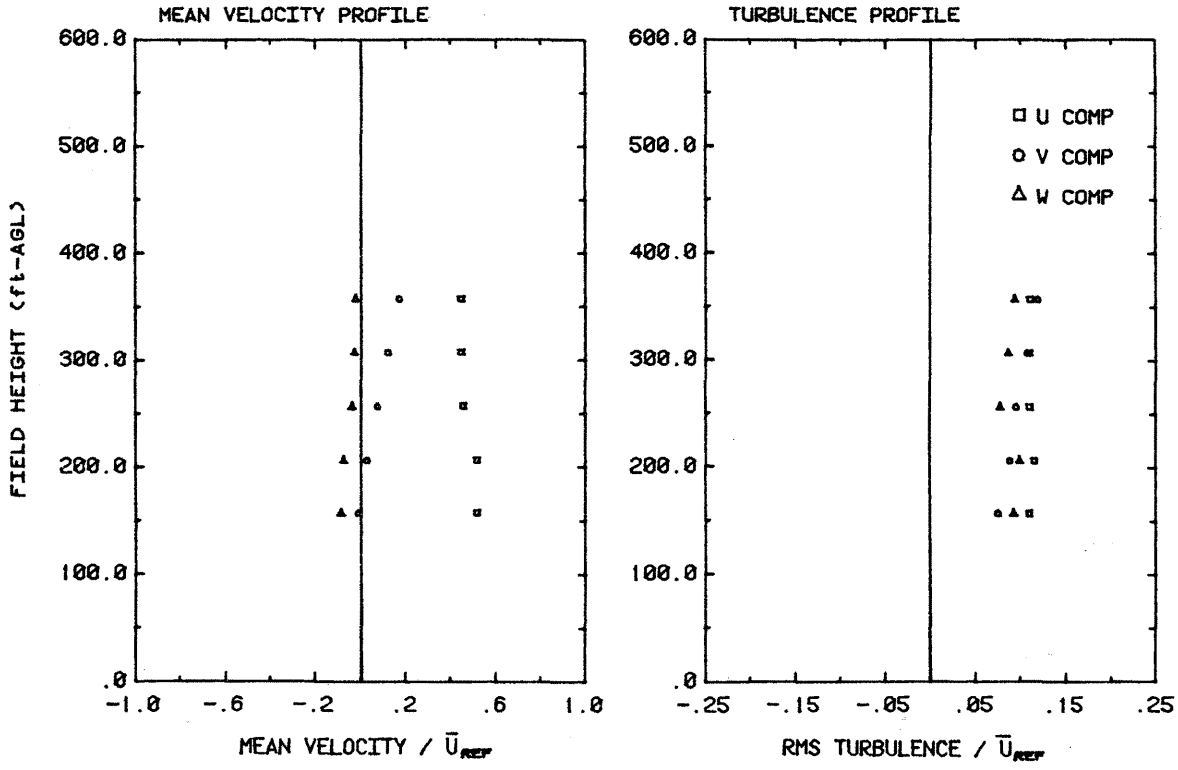


Figure E-38. Normalized mean velocities and turbulence intensity at location 04 for the south (S) wind direction.

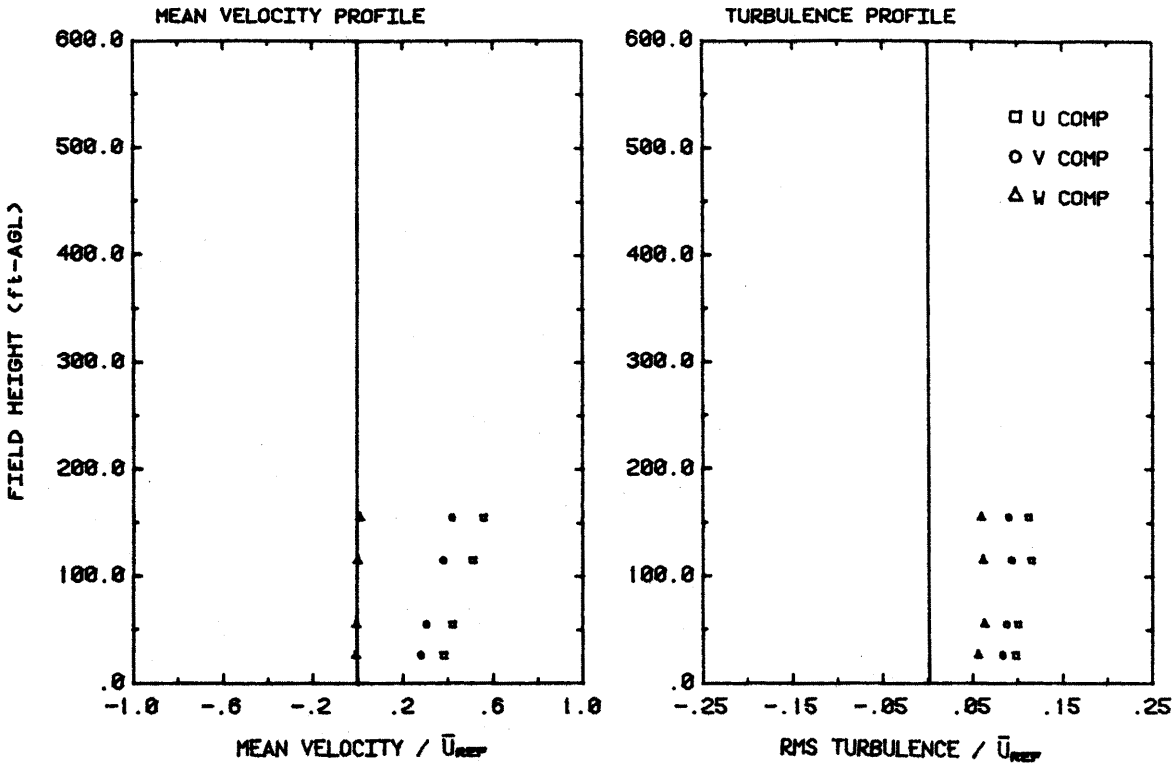


Figure E-39. Normalized mean velocities and turbulence intensity at location 05 for the south (S) wind direction.

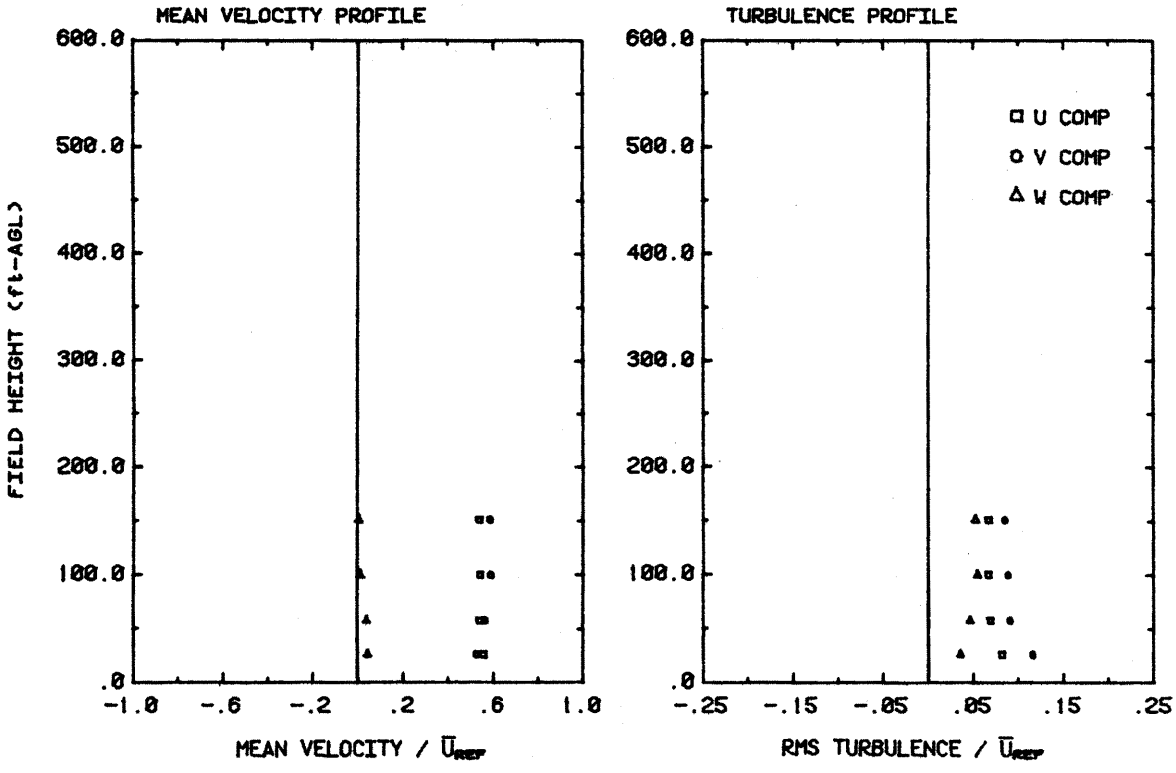


Figure E-40. Normalized mean velocities and turbulence intensity at location P1 for the south (S) wind direction.

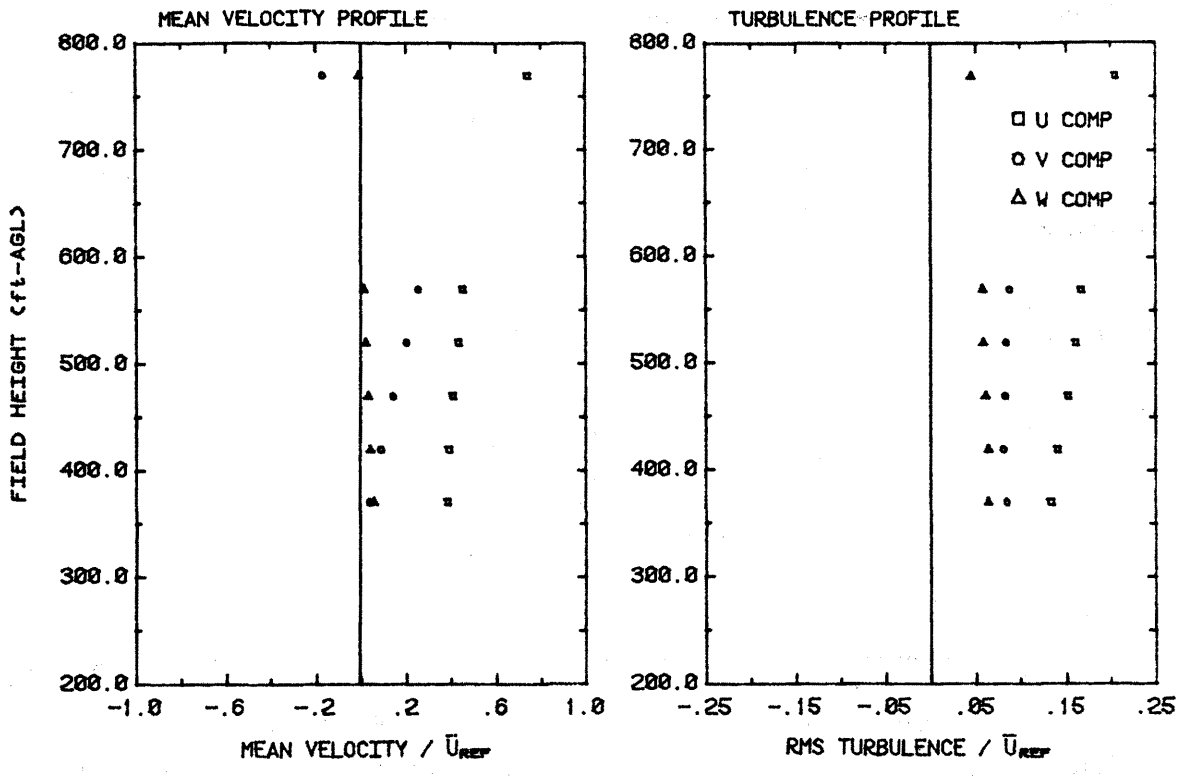


Figure E-41. Normalized mean velocities and turbulence intensity at location for P2 for the south (S) wind direction.

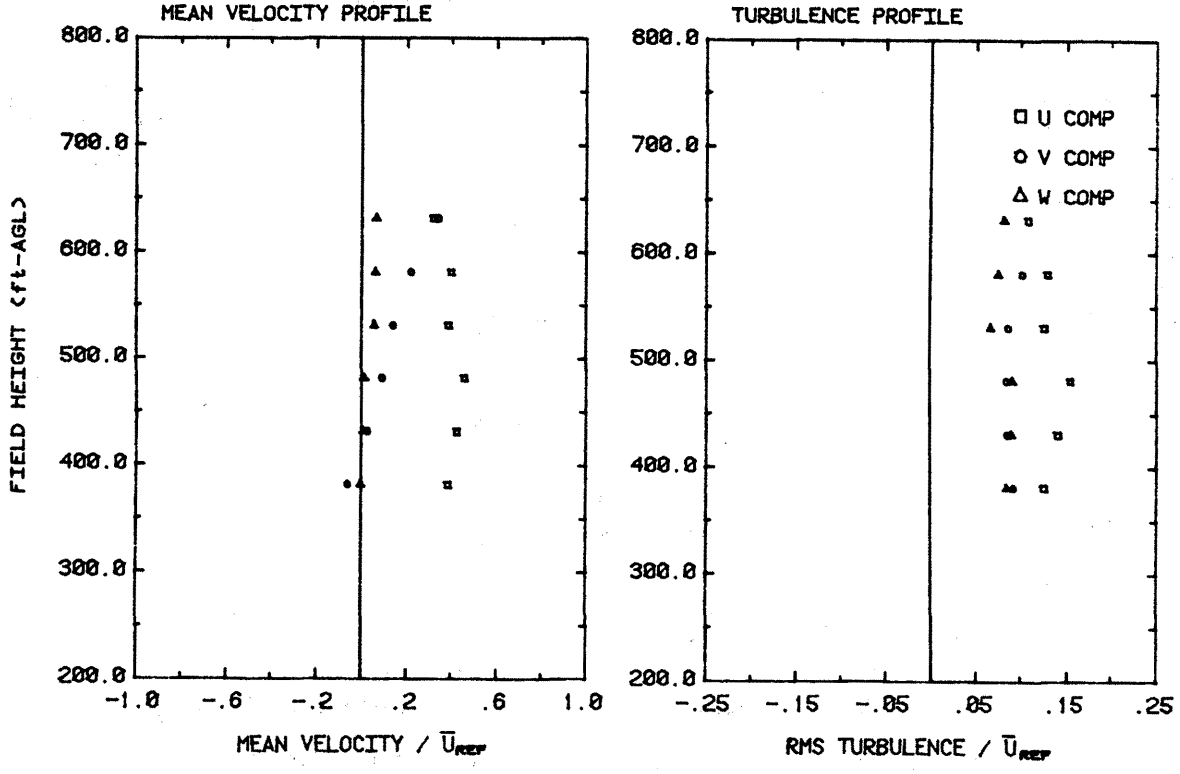


Figure E-42. Normalized mean velocities and turbulence intensity at location P3 for the south (S) wind direction.

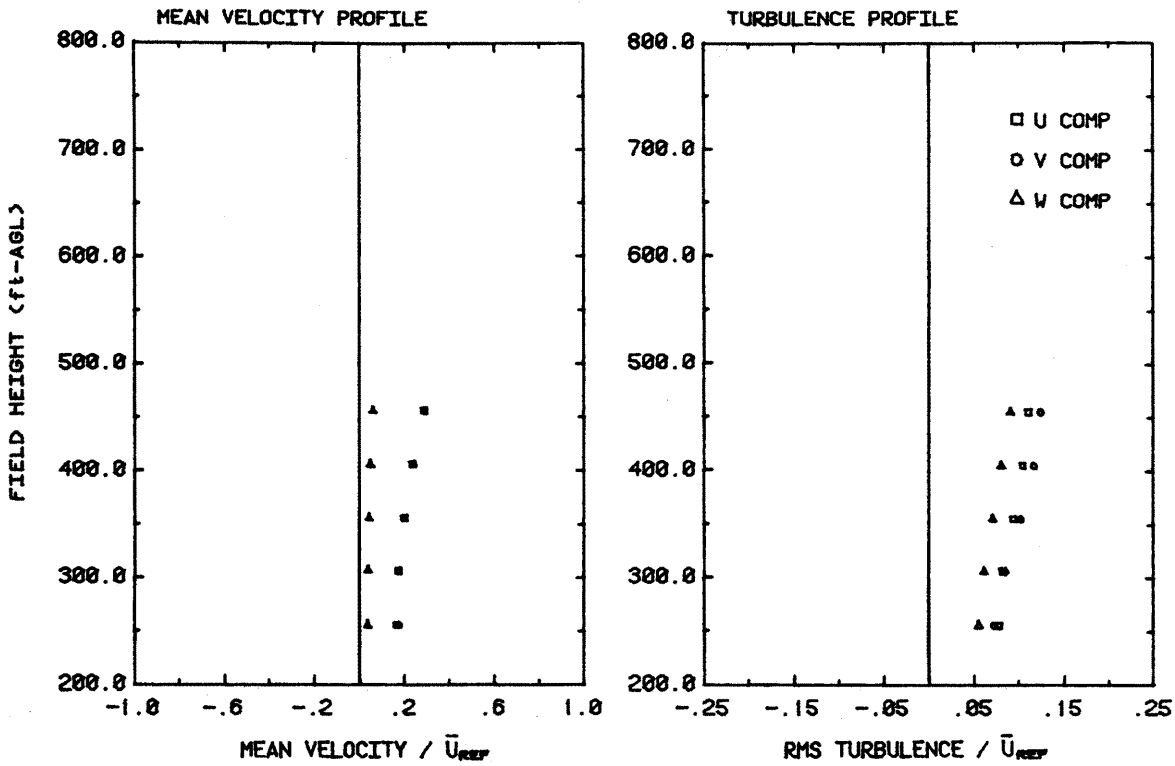


Figure E-43. Normalized mean velocities and turbulence intensity at location P4 for the south (S) wind direction.

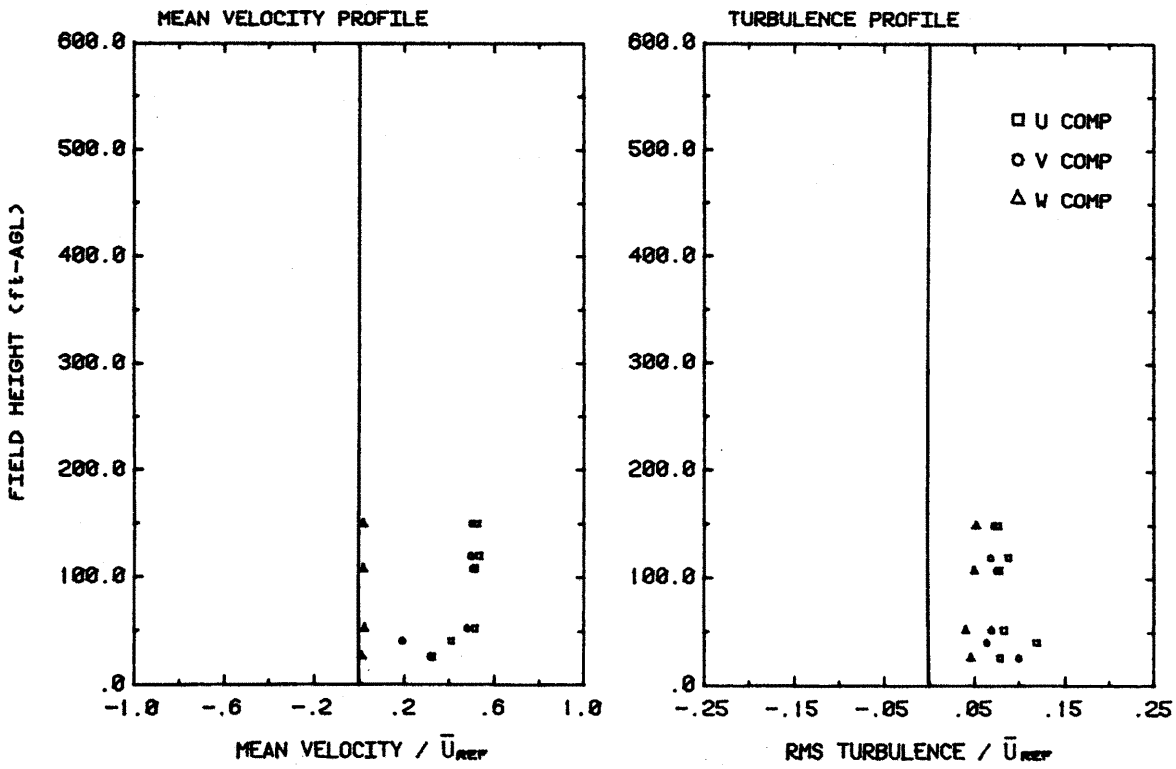


Figure E-44. Normalized mean velocities and turbulence intensity at location P5 for the south (S) wind direction.

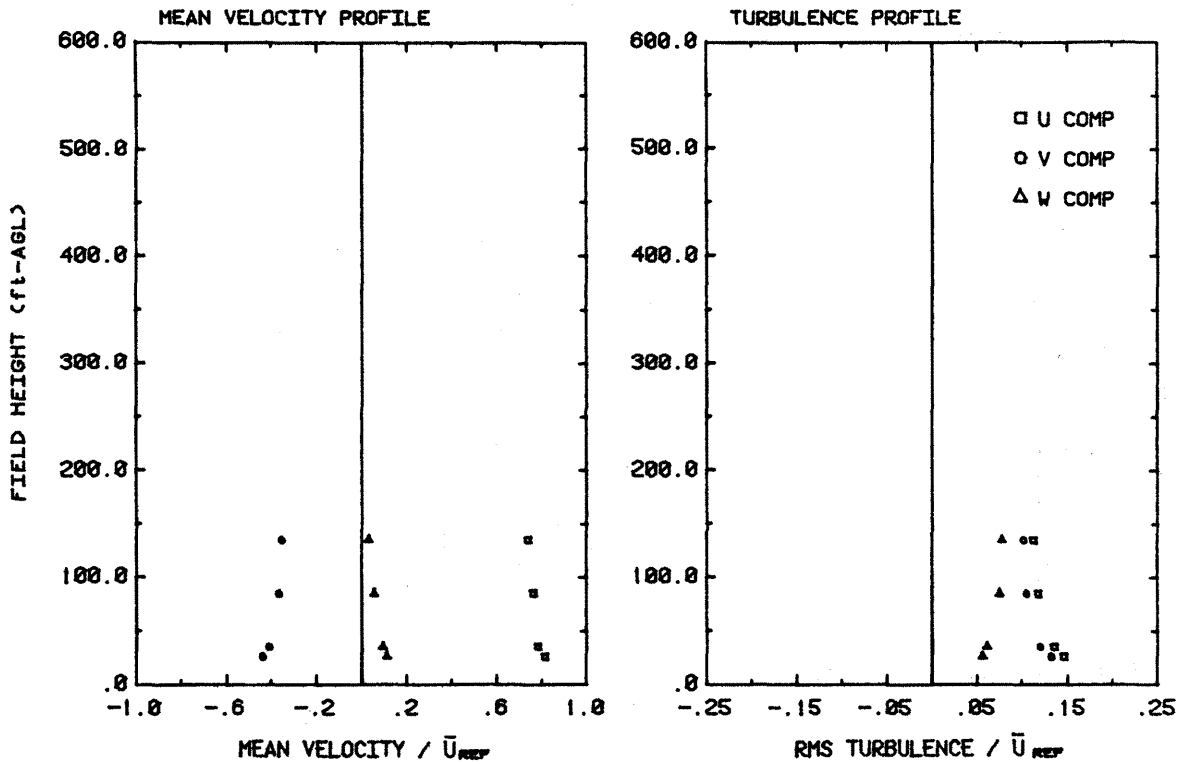


Figure E-45. Normalized mean velocities and turbulence intensity at location Q1 for the south (S) wind direction.

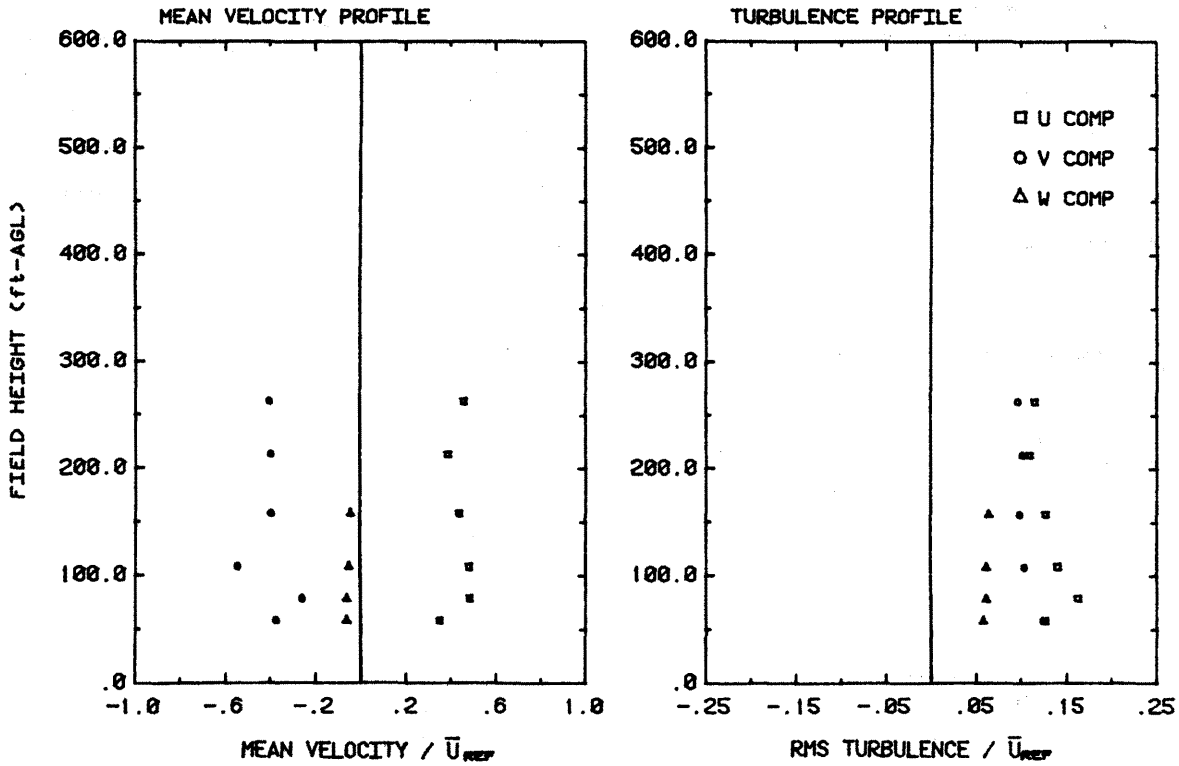


Figure E-46. Normalized mean velocities and turbulence intensity at location Q2 for the south (S) wind direction.

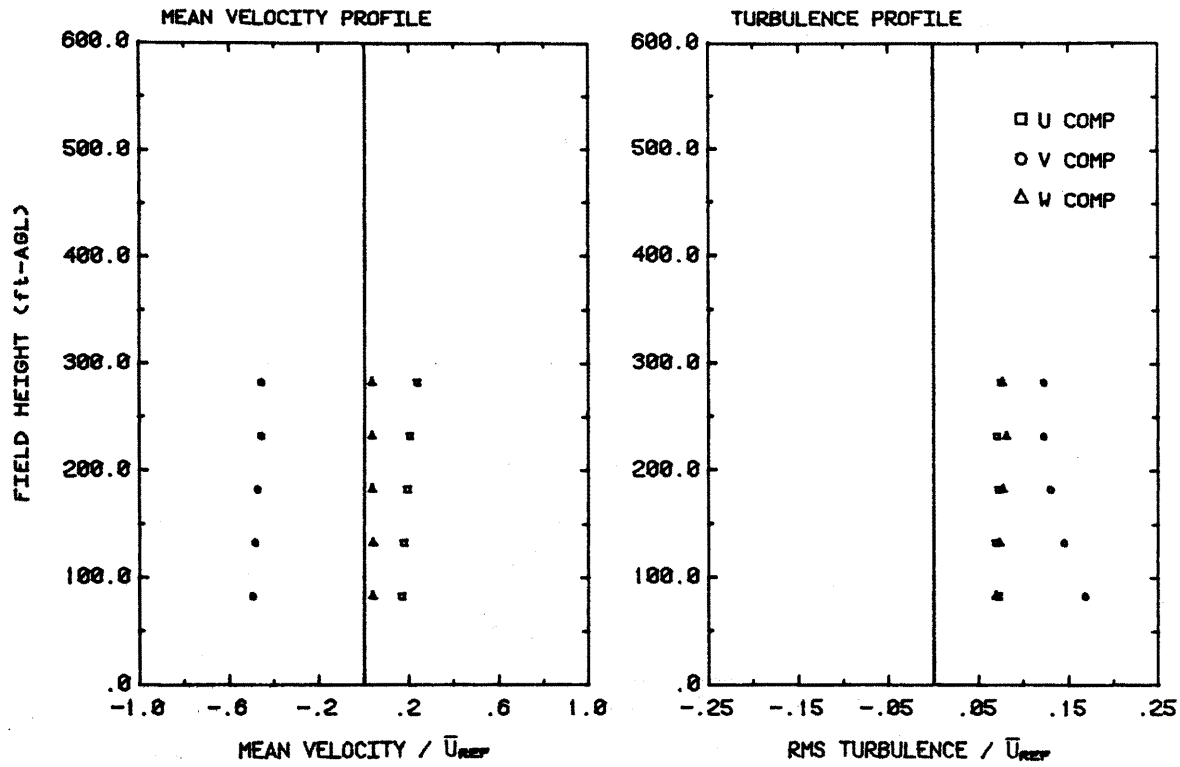


Figure E-47. Normalized mean velocities and turbulence intensity at location Q3 for the south (S) wind direction.

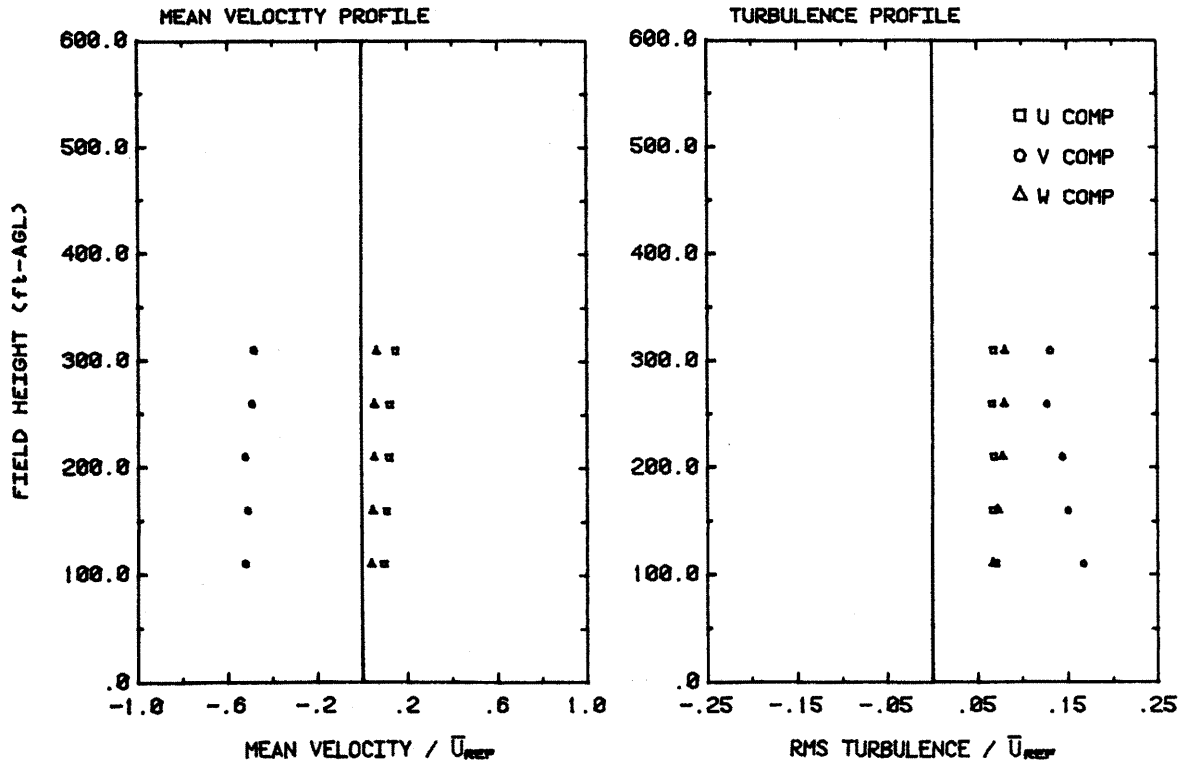


Figure E-48. Normalized mean velocities and turbulence intensity at location Q4 for the south (S) wind direction.

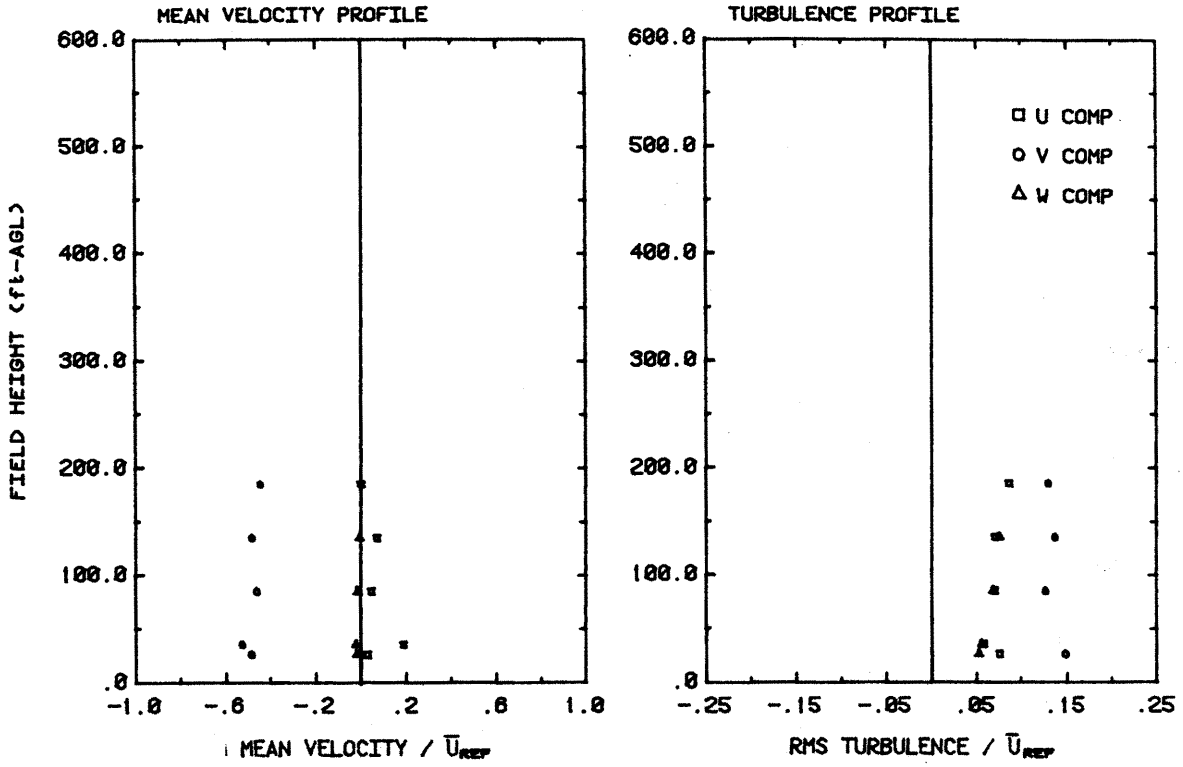


Figure E-49. Normalized mean velocities and turbulence intensity at location Q5 for the south (S) wind direction.

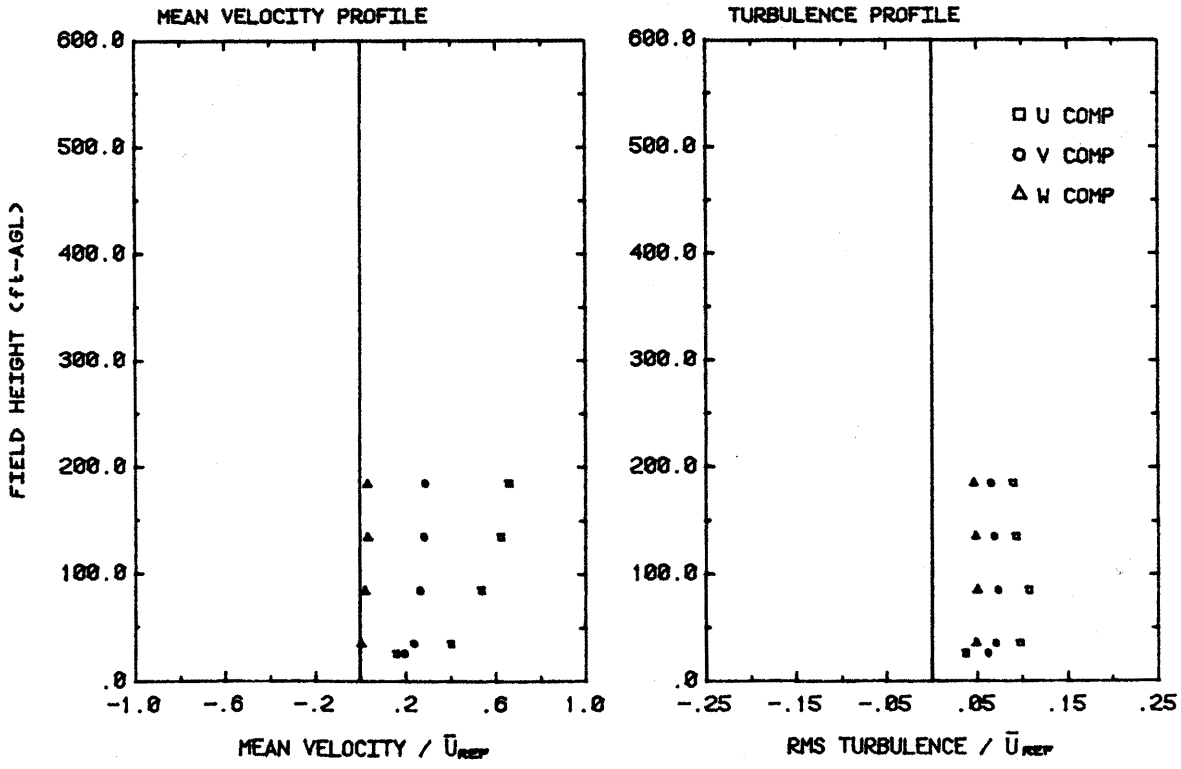


Figure E-50. Normalized mean velocities and turbulence intensity at location A1 for the south southwest (SSW) wind direction.

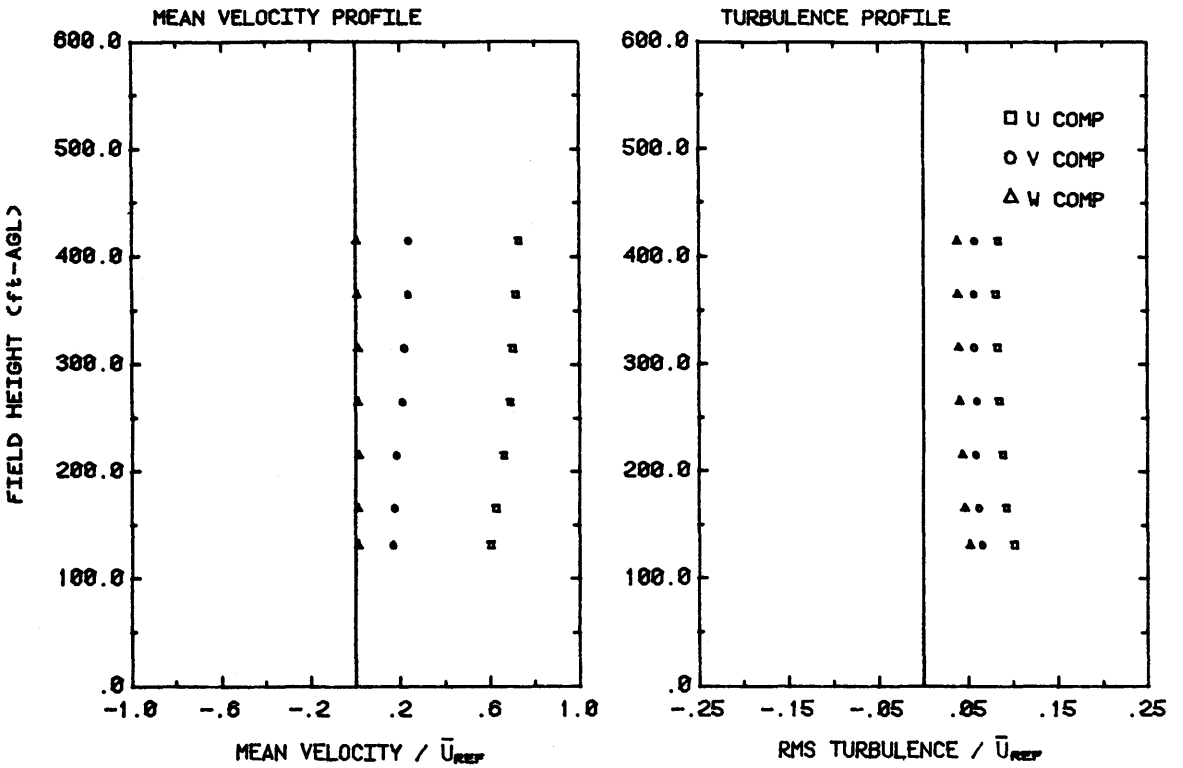


Figure E-51. Normalized mean velocities and turbulence intensity at location A2 for the south southwest (SSW) wind direction.

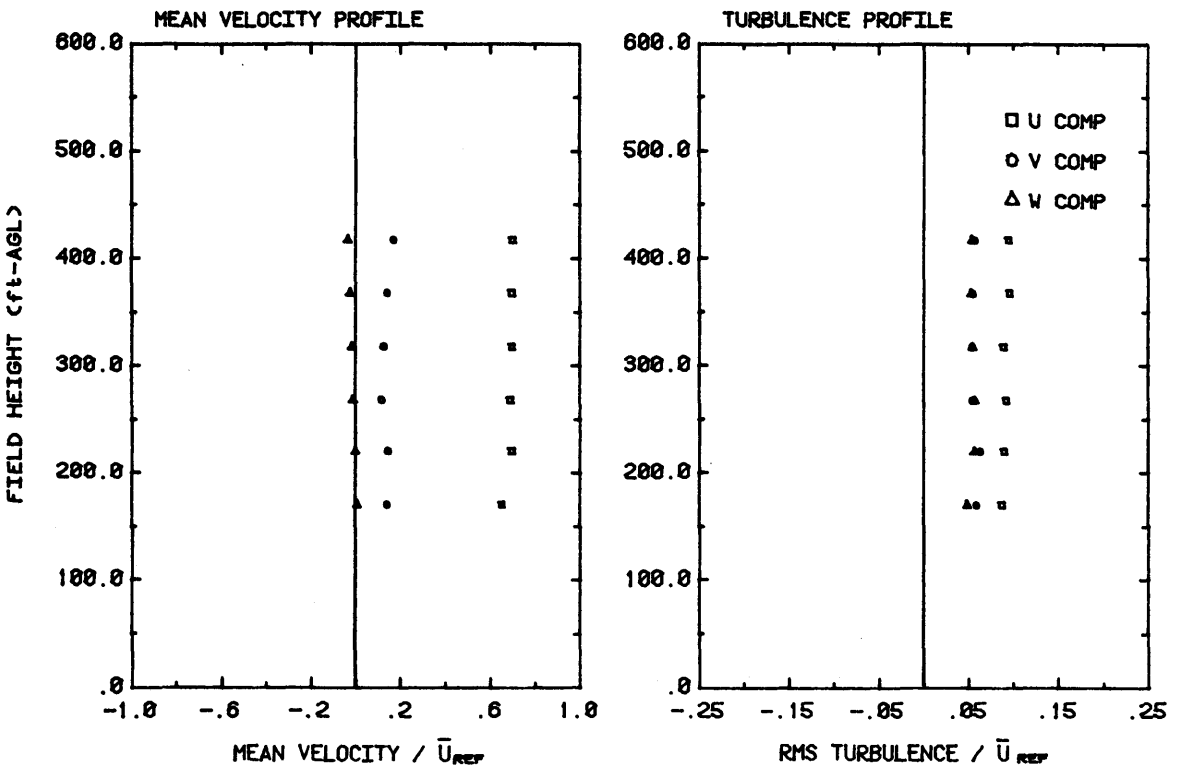


Figure E-52. Normalized mean velocities and turbulence intensity at location A3 for the south southwest (SSW) wind direction.

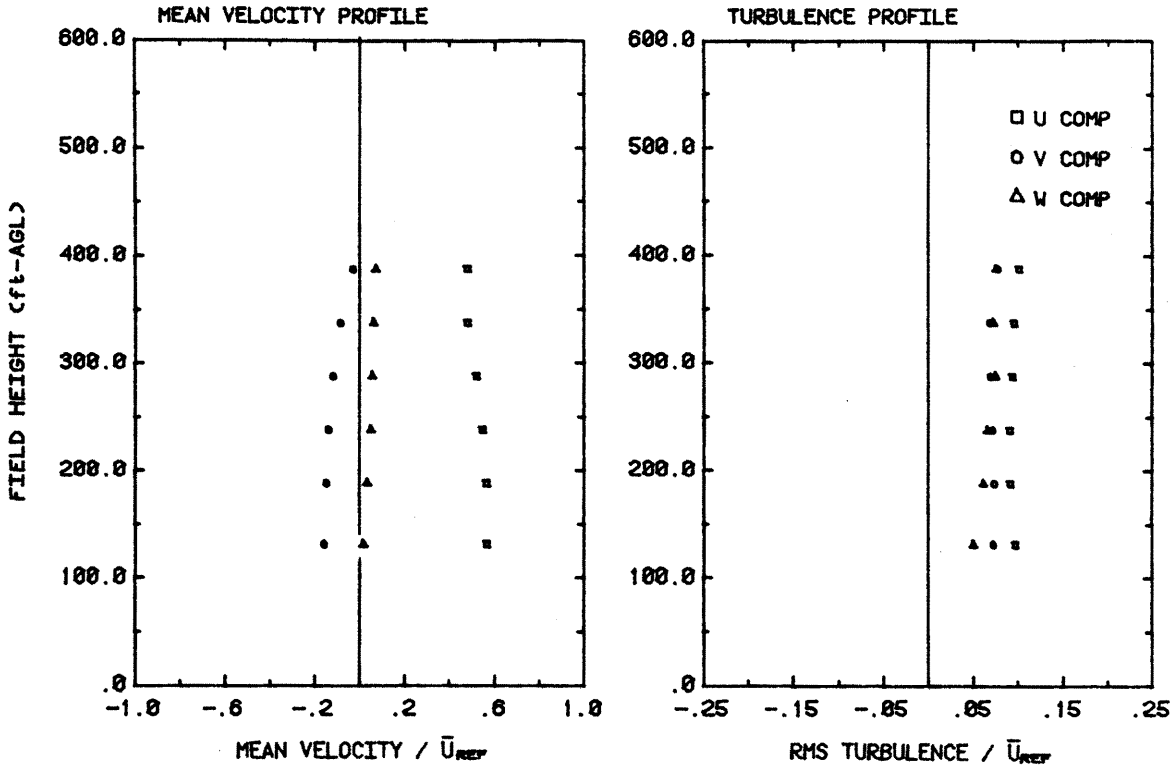


Figure E-53. Normalized mean velocities and turbulence intensity at location A4 for the south southwest (SSW) wind direction.

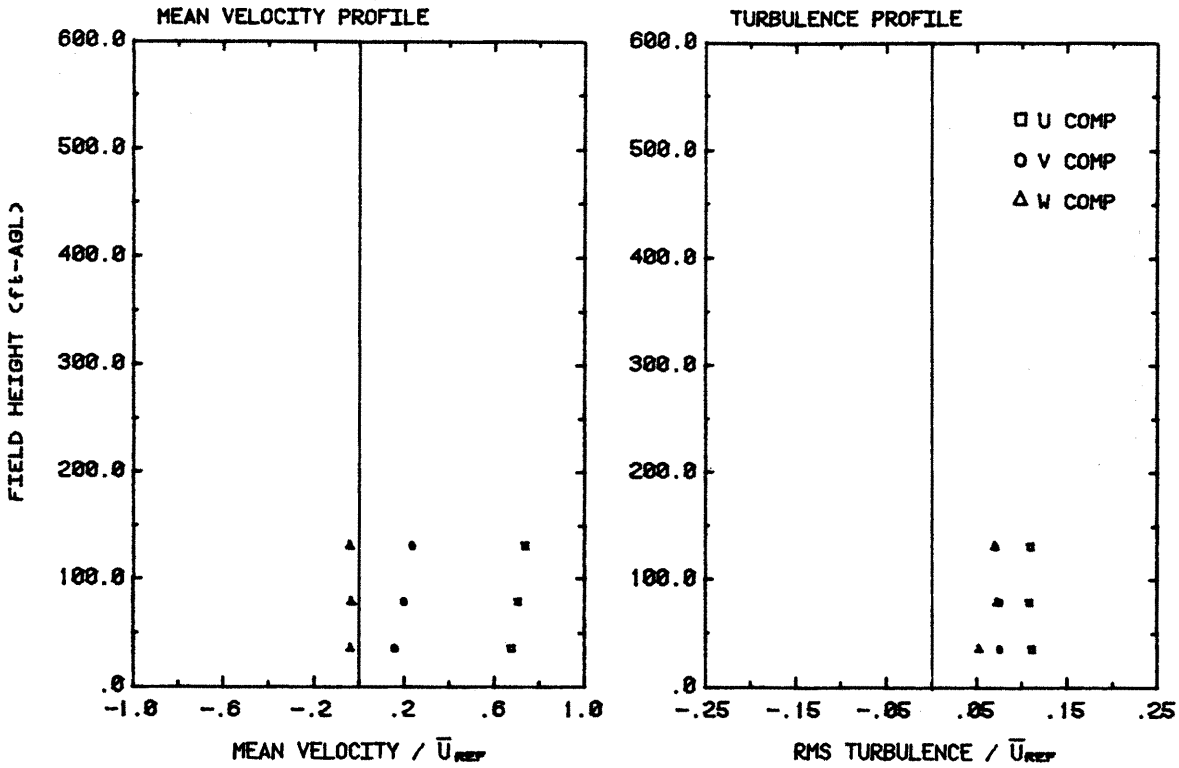


Figure E-54. Normalized mean velocities and turbulence intensity at location A5 for the south southwest (SSW) wind direction.

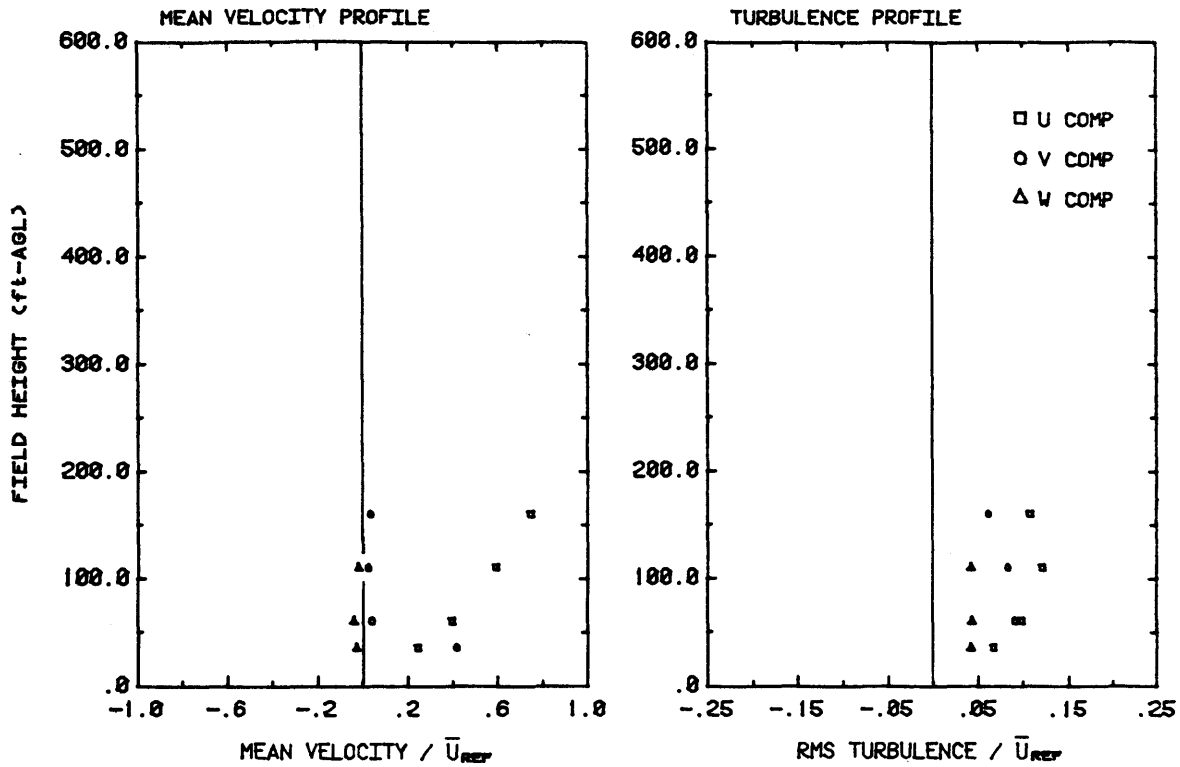


Figure E-55. Normalized mean velocities and turbulence intensity at location B1 for the south southwest (SSW) wind direction.

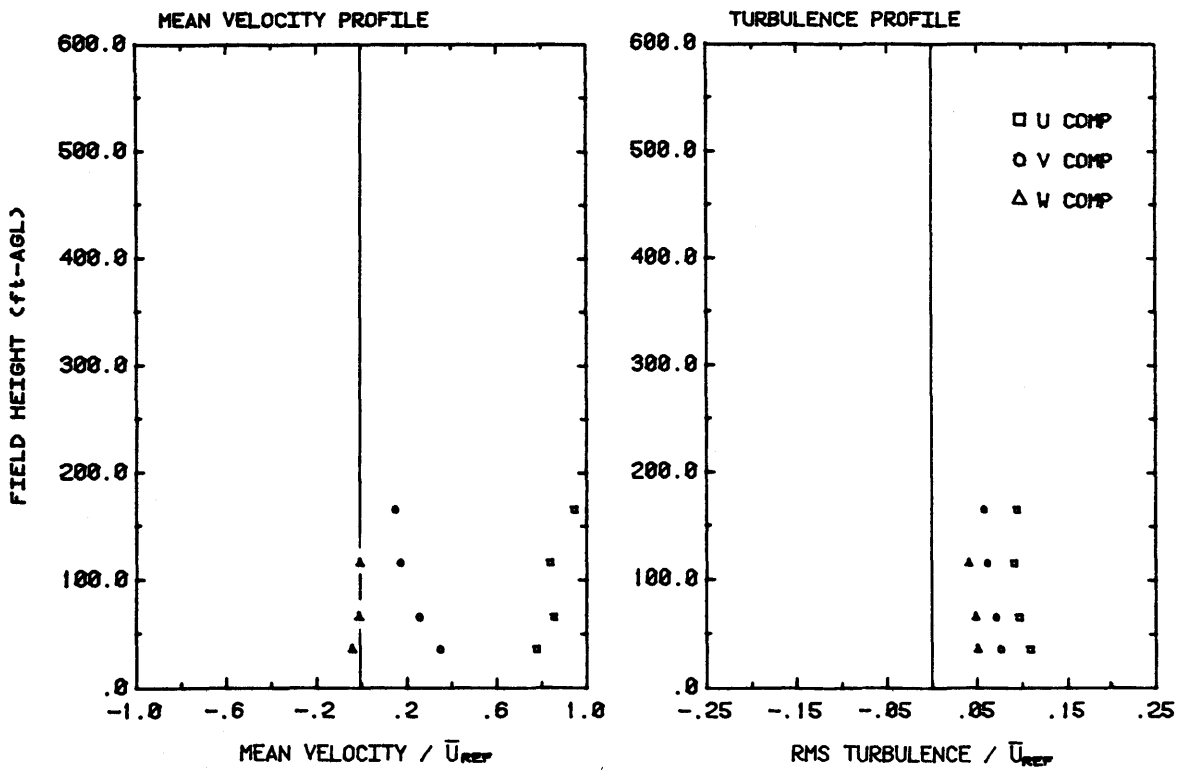


Figure E-56. Normalized mean velocities and turbulence intensity at location B5 for the south southwest (SSW) wind direction.

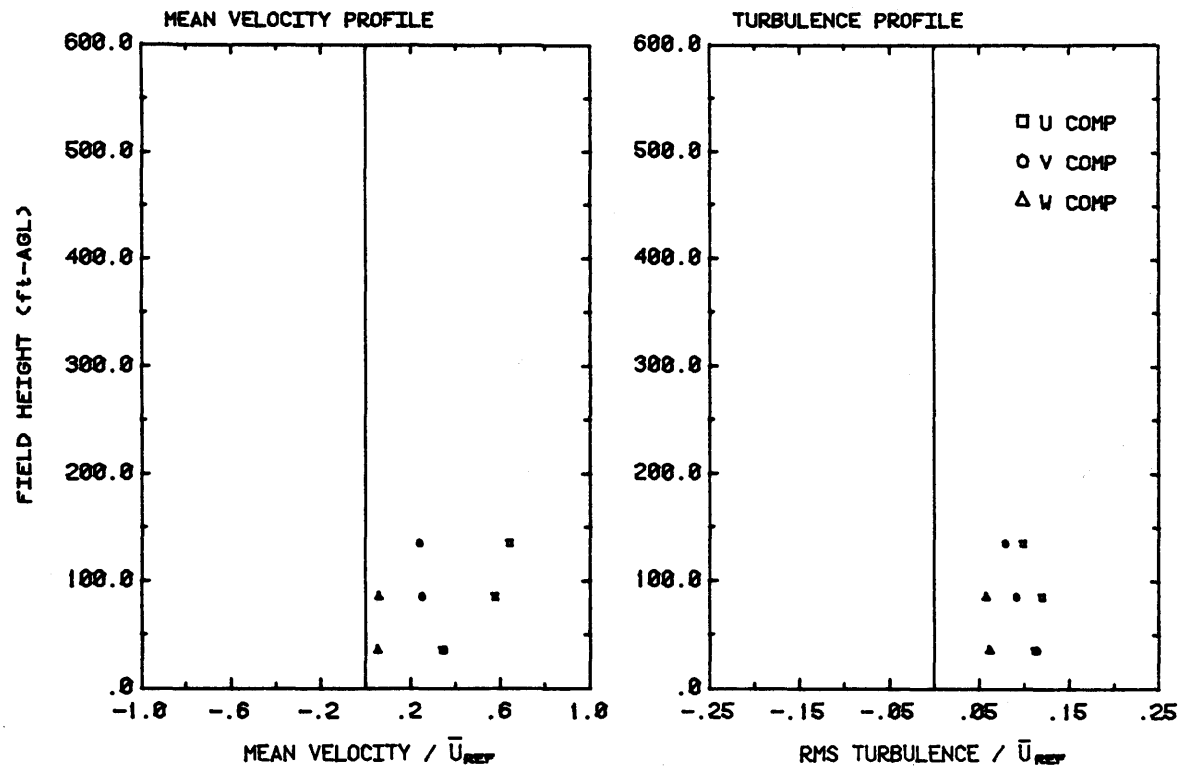


Figure E-57. Normalized mean velocities and turbulence intensity at location C1 for the south southwest (SSW) wind direction.

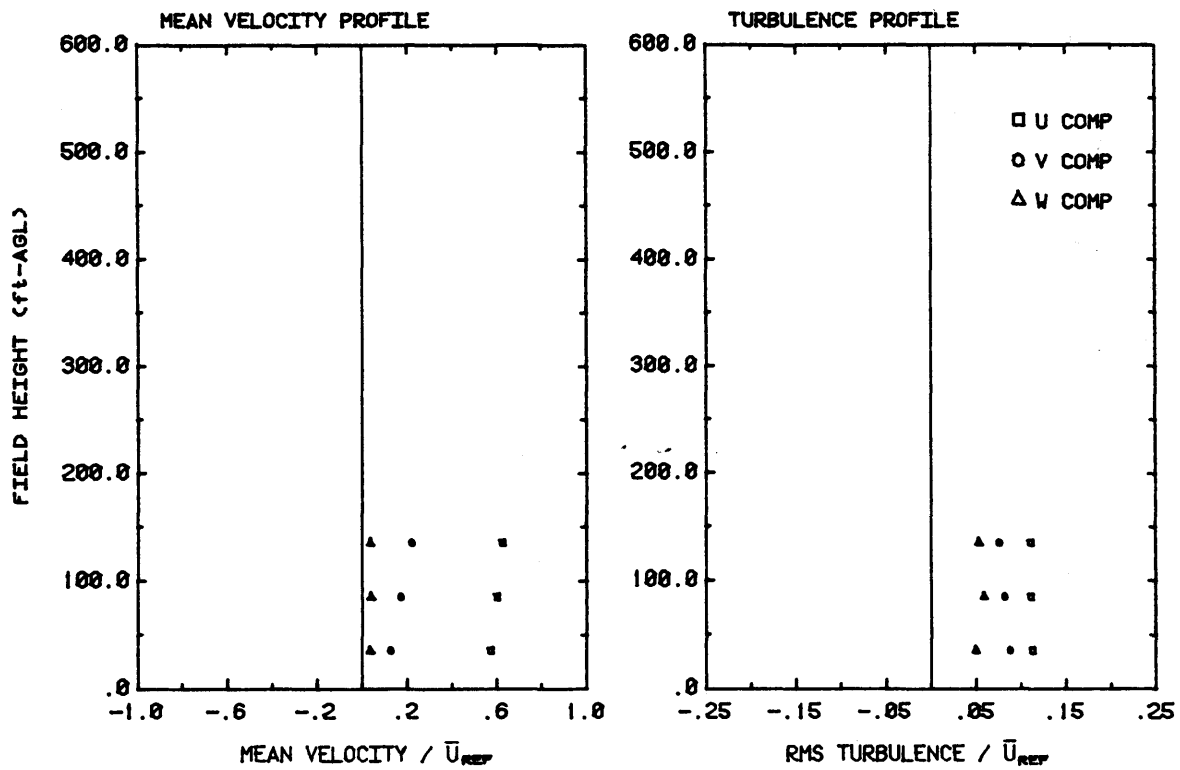


Figure E-58. Normalized mean velocities and turbulence intensity at location C5 for the south southwest (SSW) wind direction.

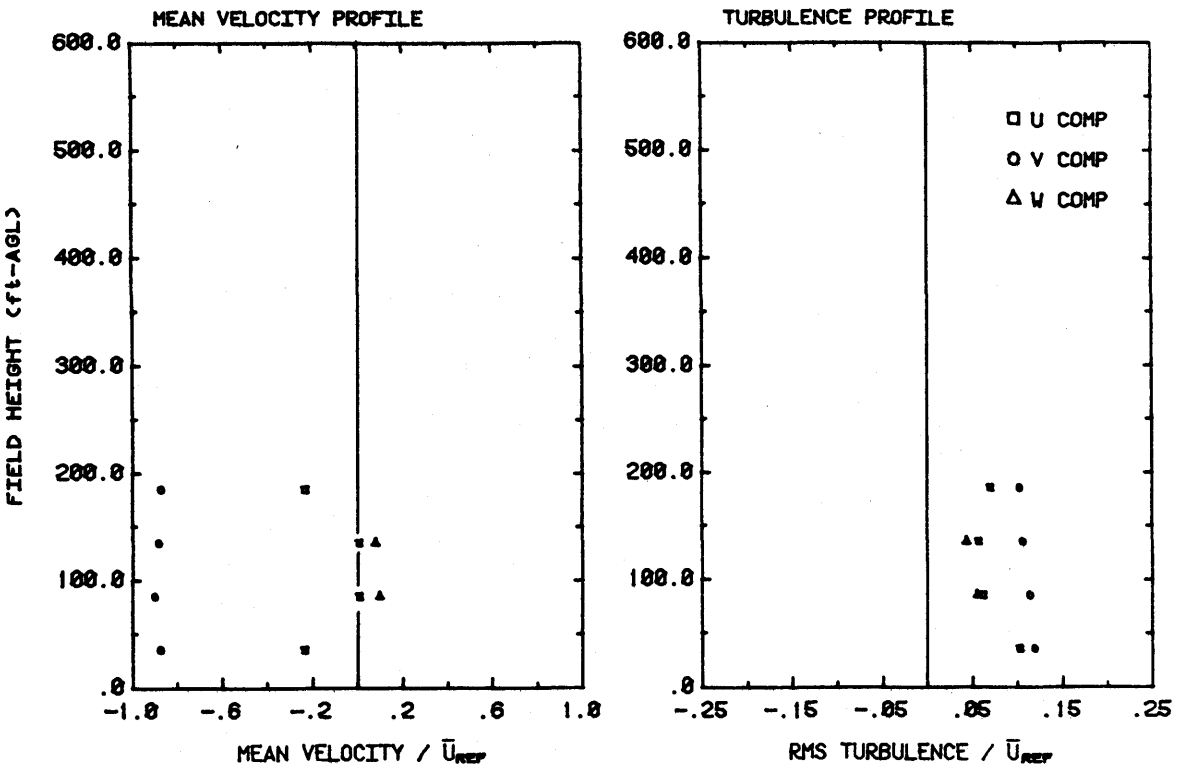


Figure E-59. Normalized mean velocities and turbulence intensity at location F1 for the south southwest (SSW) wind direction.

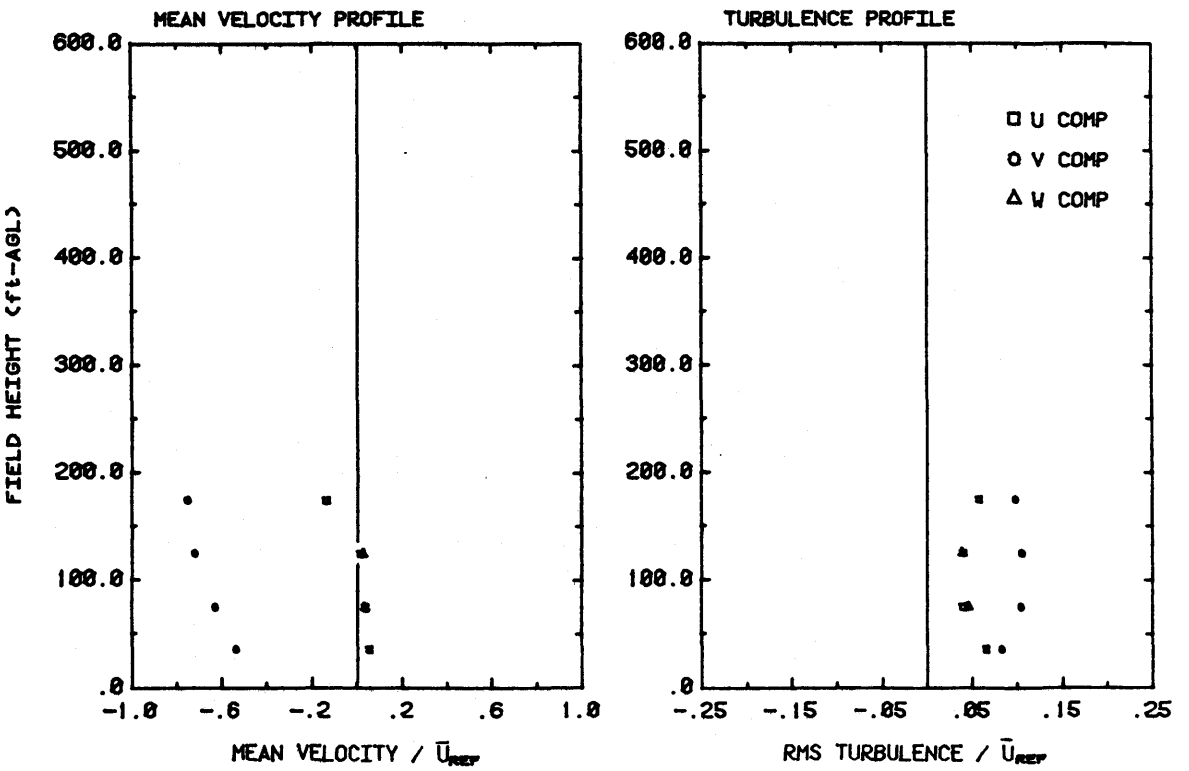


Figure E-60. Normalized mean velocities and turbulence intensity at location F5 for the south southwest (SSW) wind direction.

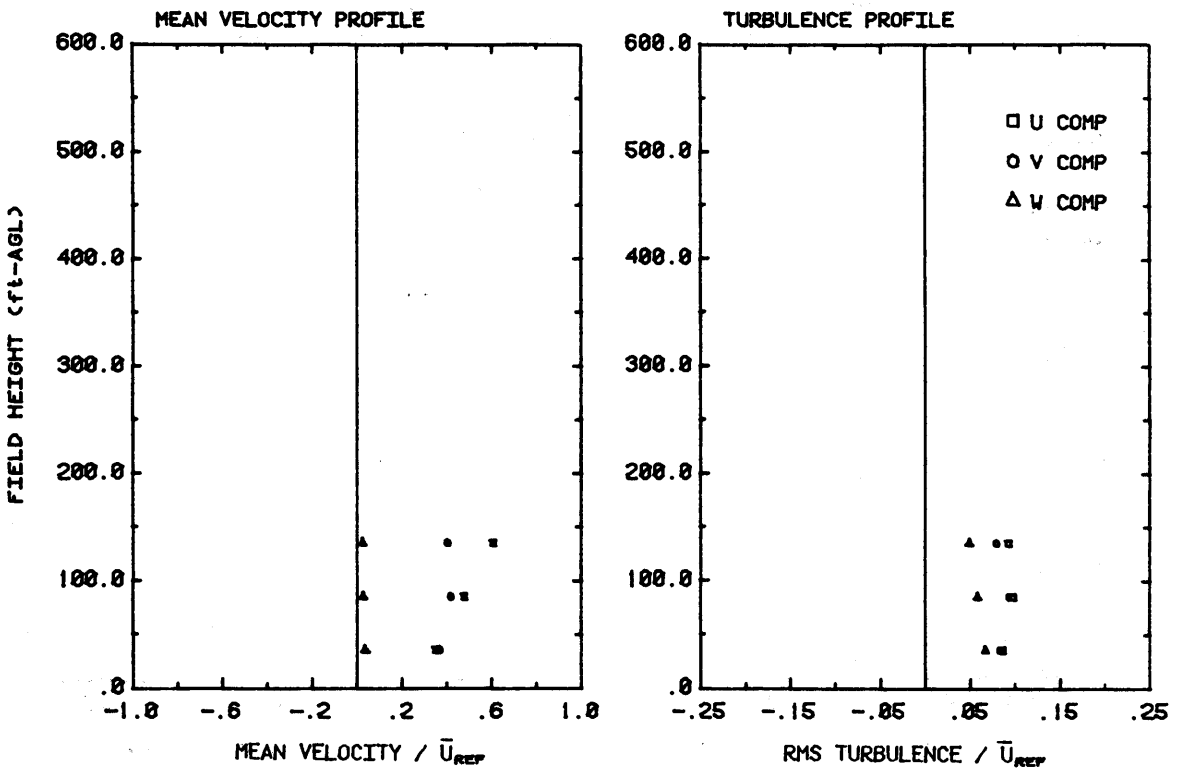


Figure E-61. Normalized mean velocities and turbulence intensity at location G1 for the south southwest (SSW) wind direction.

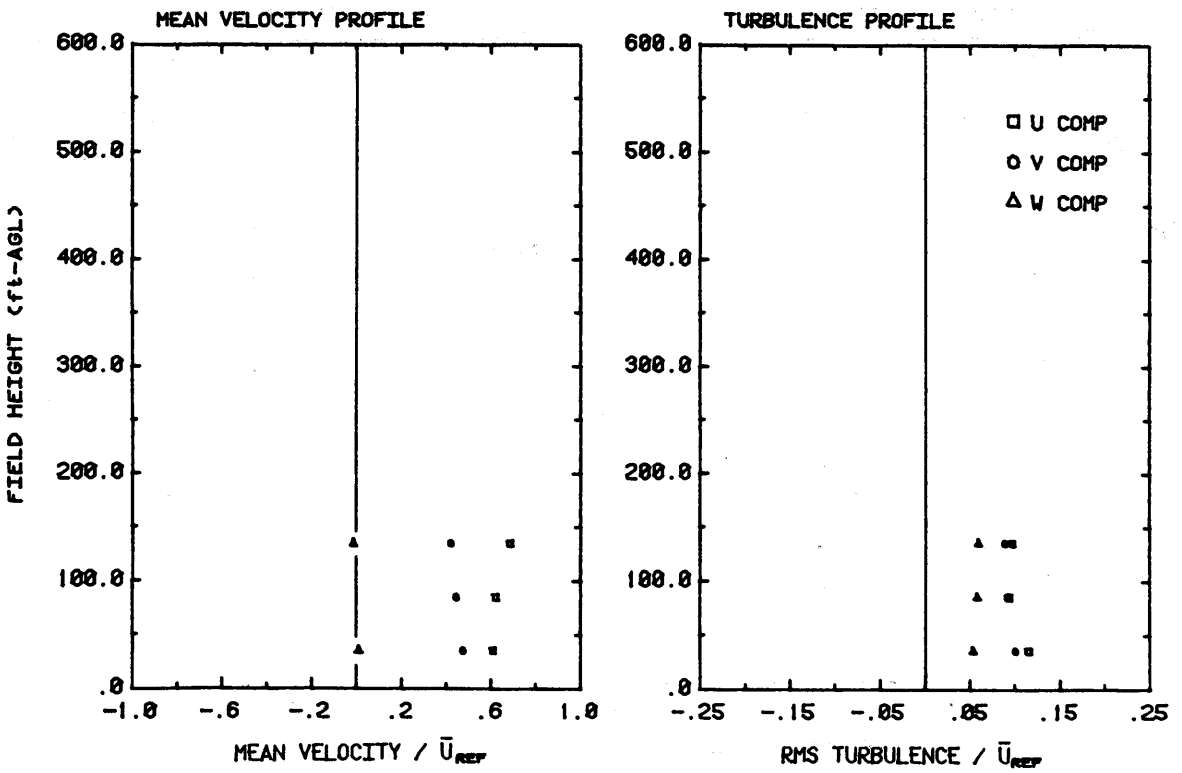


Figure E-62. Normalized mean velocities and turbulence intensity at location G5 for the south southwest (SSW) wind direction.

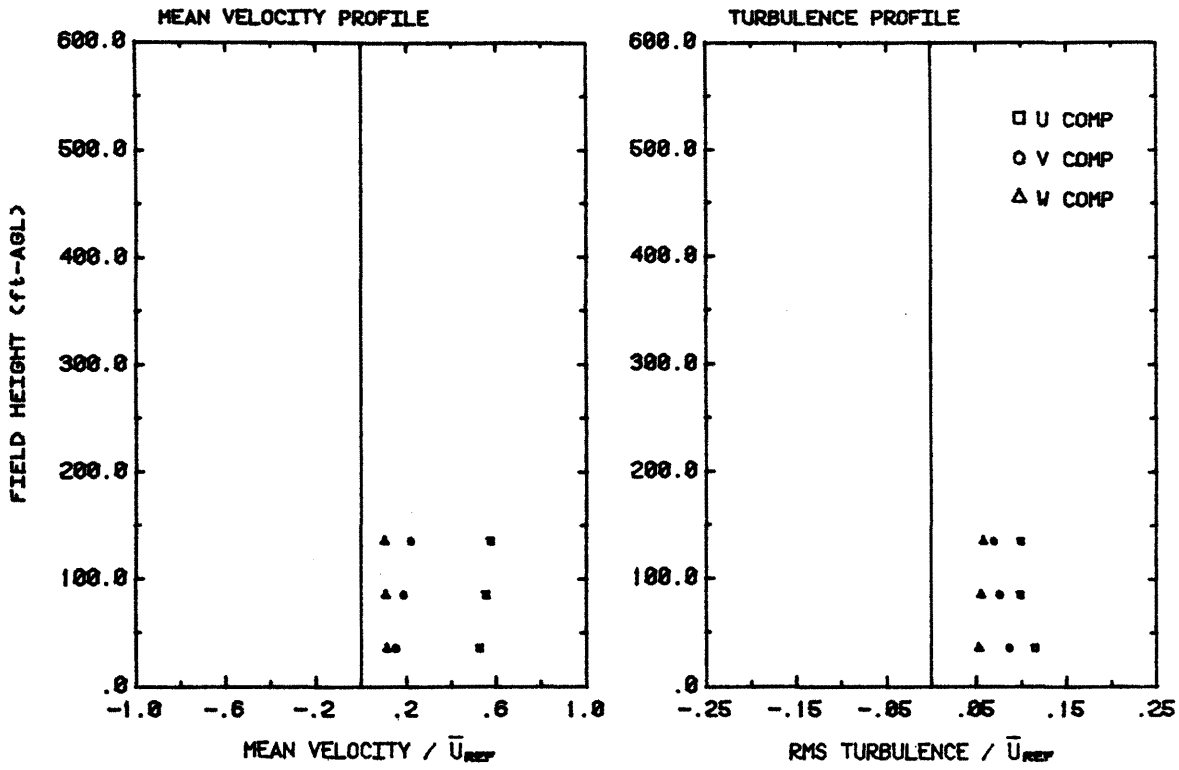


Figure E-63. Normalized mean velocities and turbulence intensity at location H1 for the south southwest (SSW) wind direction.

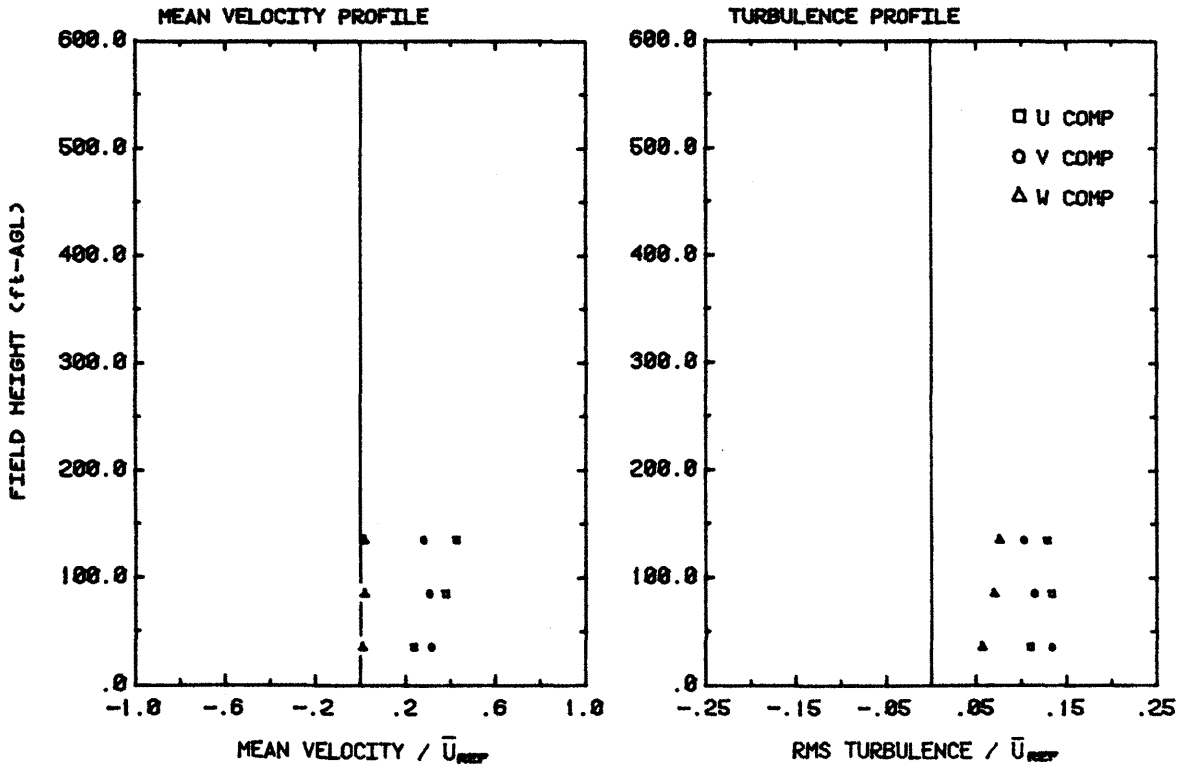


Figure E-64. Normalized mean velocities and turbulence intensity at location H5 for the south southwest (SSW) wind direction.

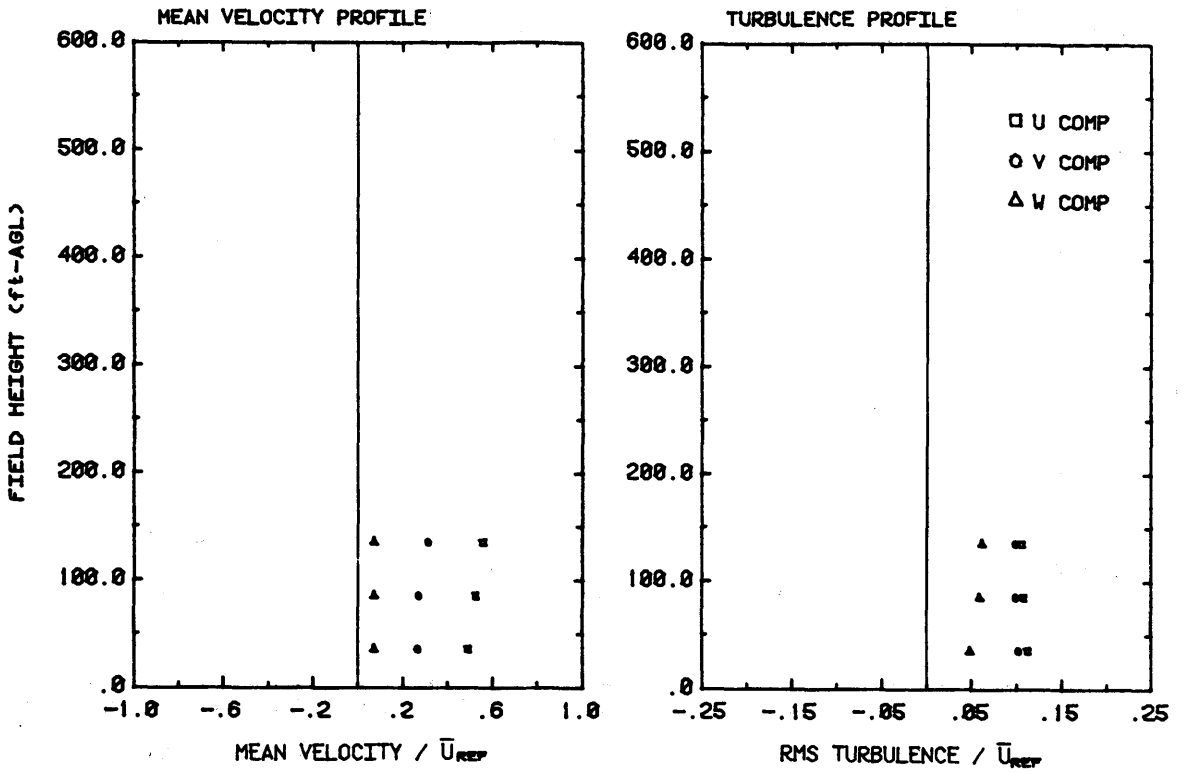


Figure E-65. Normalized mean velocities and turbulence intensity at location J5 for the south southwest (SSW) wind direction.

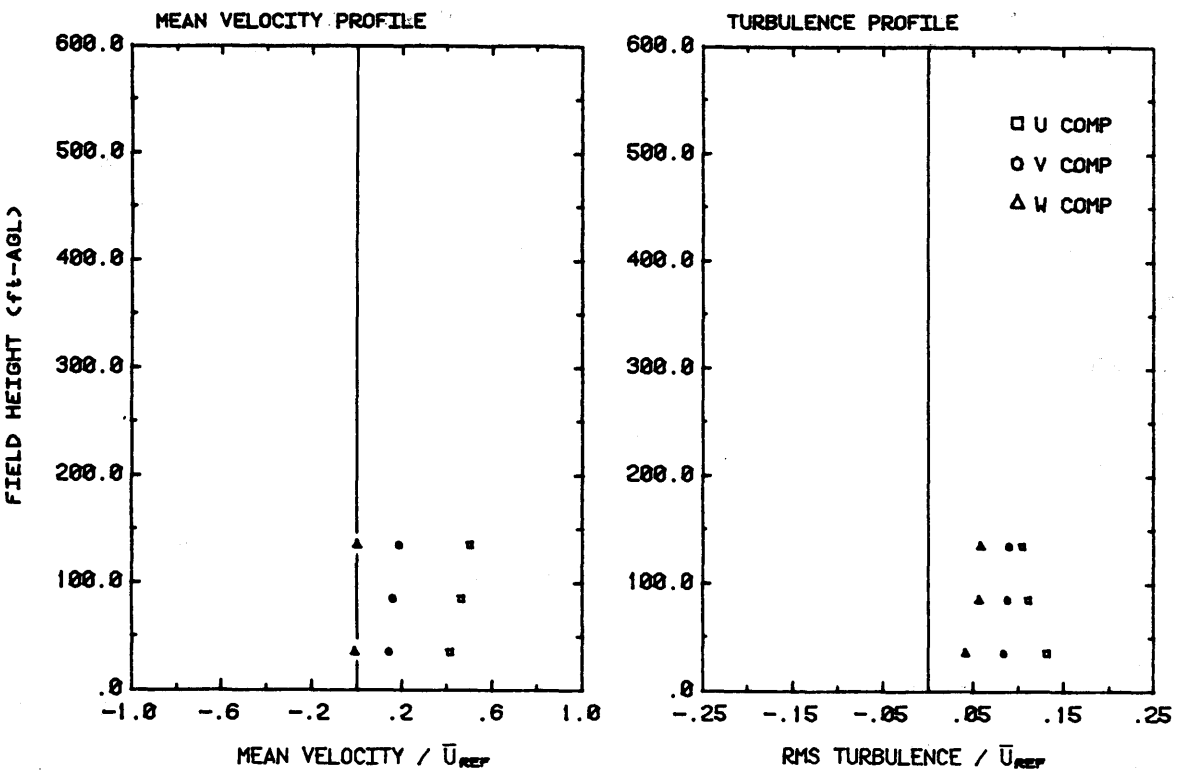


Figure E-66. Normalized mean velocities and turbulence intensity at location K5 for the south southwest (SSW) wind direction.

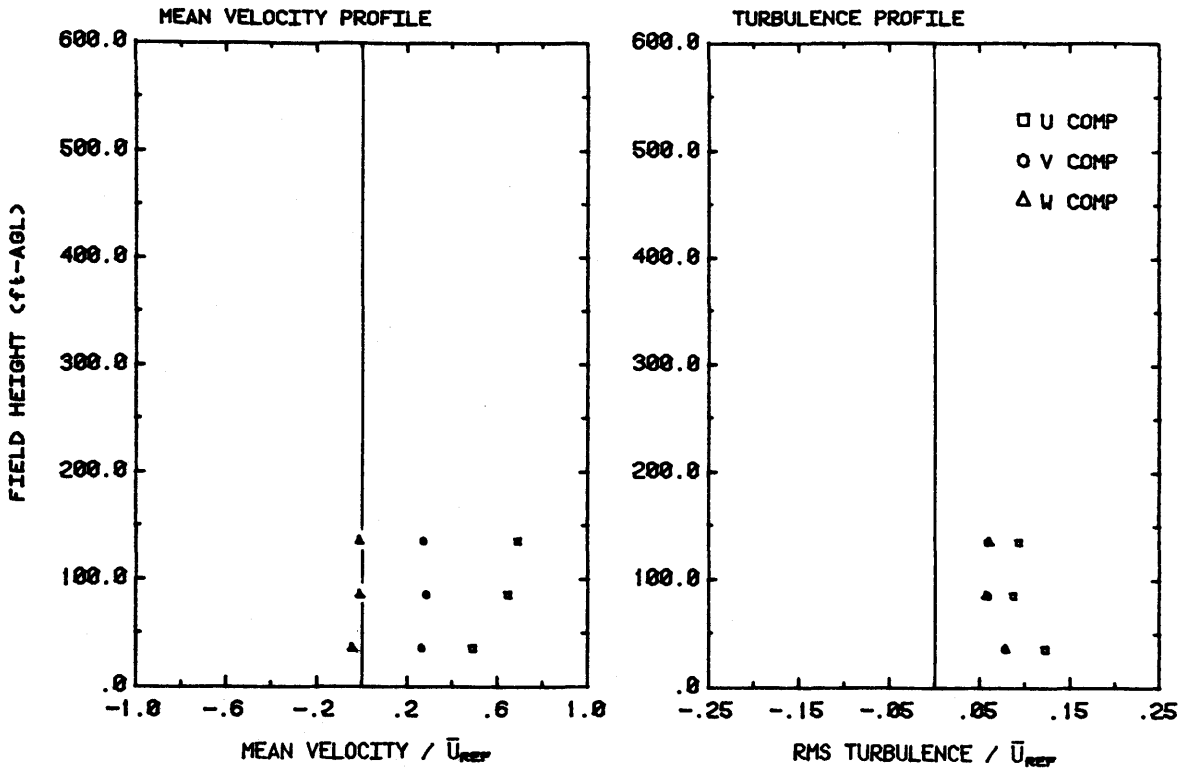


Figure E-67. Normalized mean velocities and turbulence intensity at location L5 for the south southwest (SSW) wind direction.

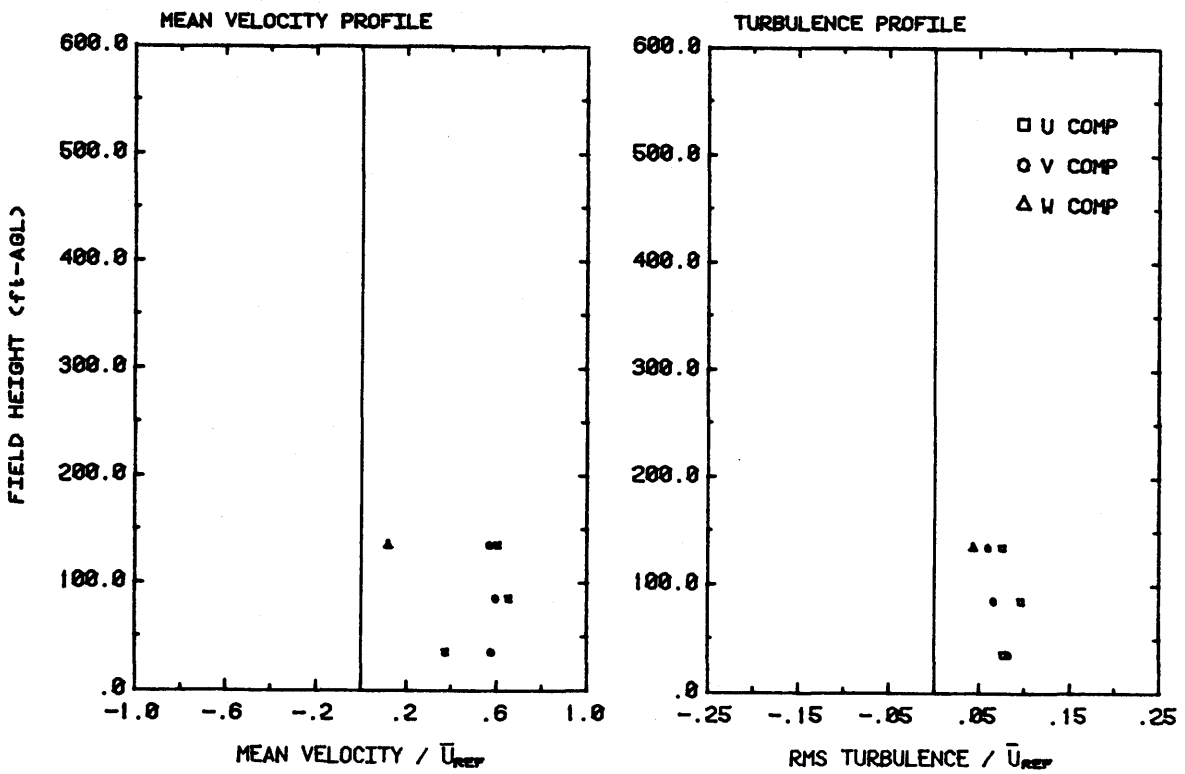


Figure E-68. Normalized mean velocities and turbulence intensity at location N1 for the south southwest (SSW) wind direction.

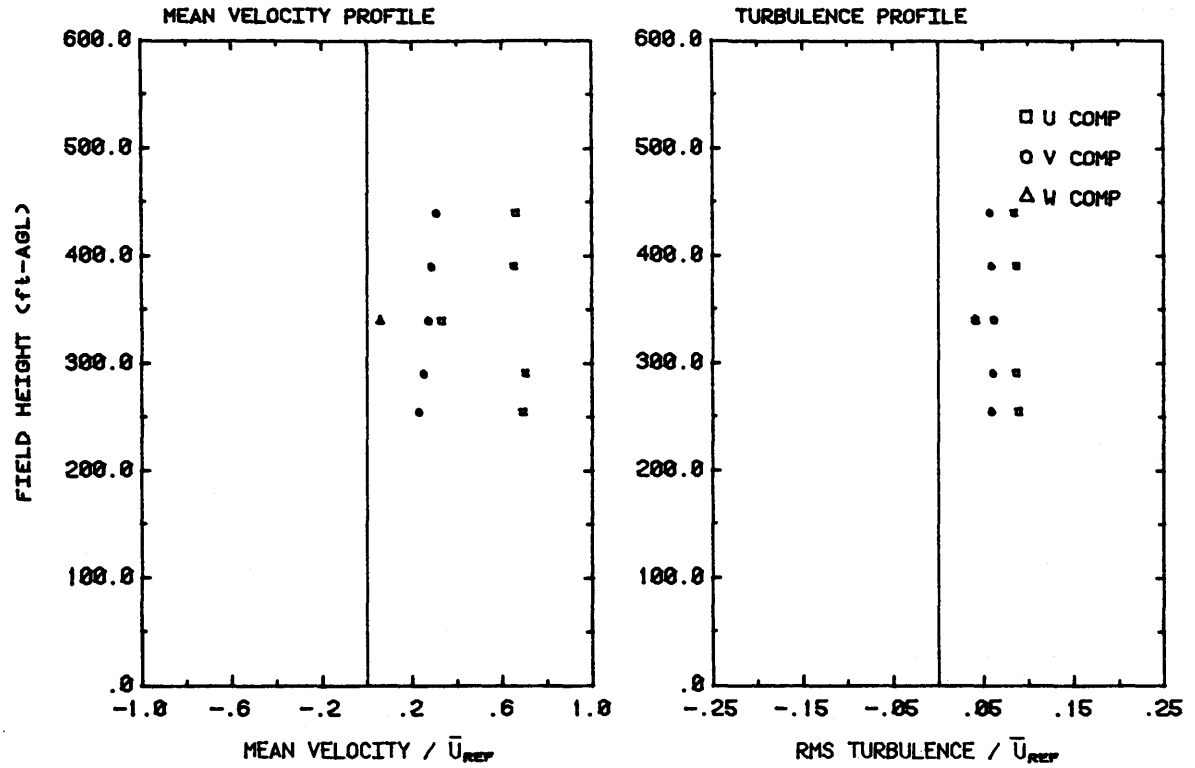


Figure E-69. Normalized mean velocities and turbulence intensity at location N2 for the south southwest (SSW) wind direction.

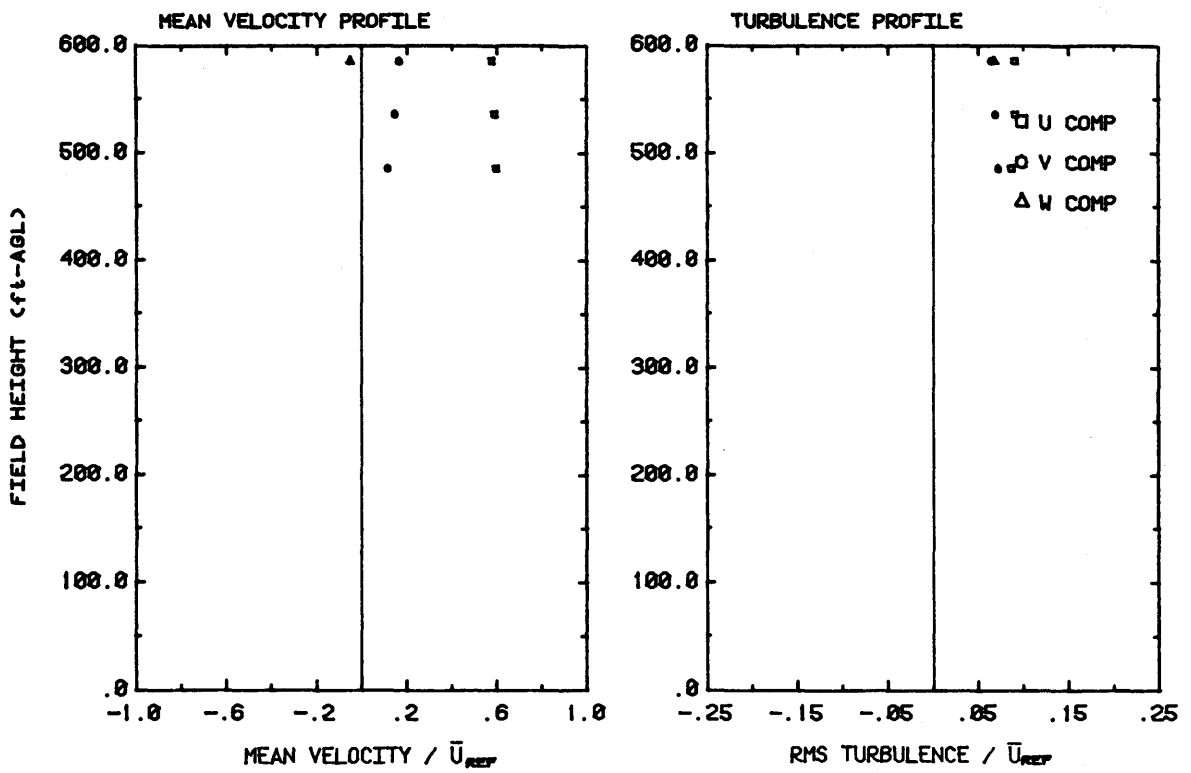


Figure E-70. Normalized mean velocities and turbulence intensity at location N3 for the south southwest (SSW) wind direction.

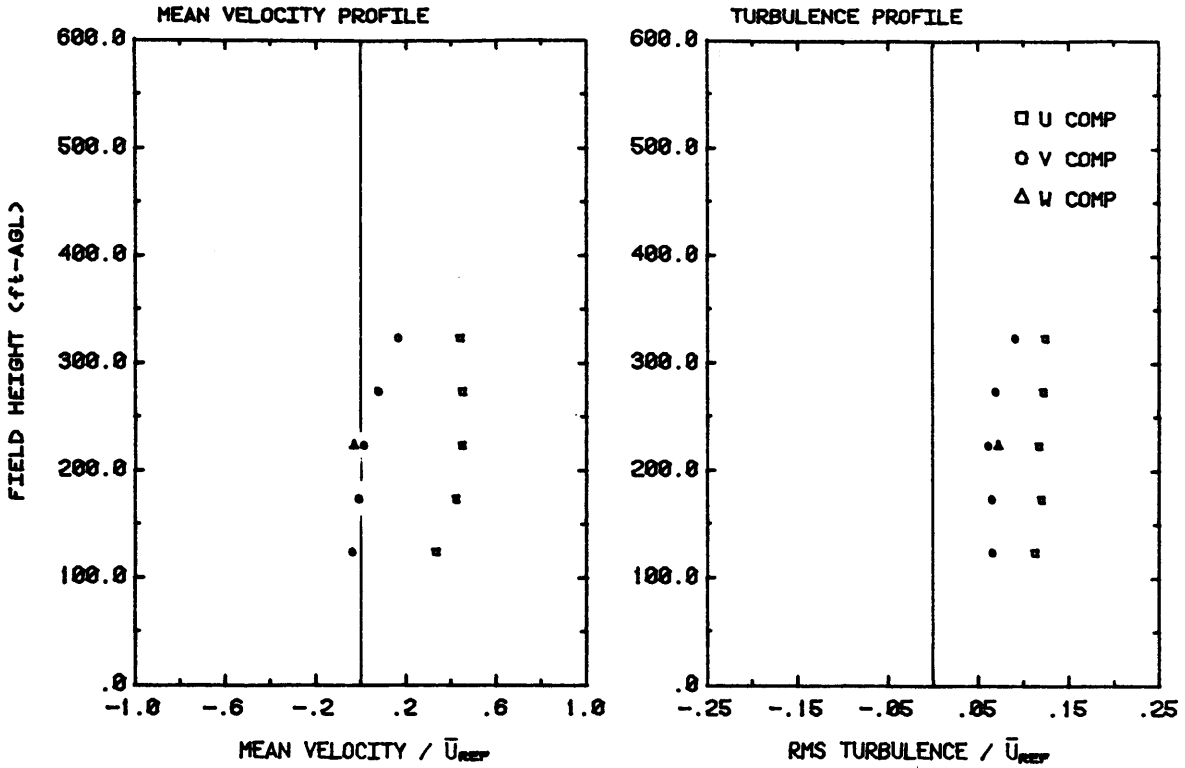


Figure E-71. Normalized mean velocities and turbulence intensity at location N4 for the south southwest (SSW) wind direction.

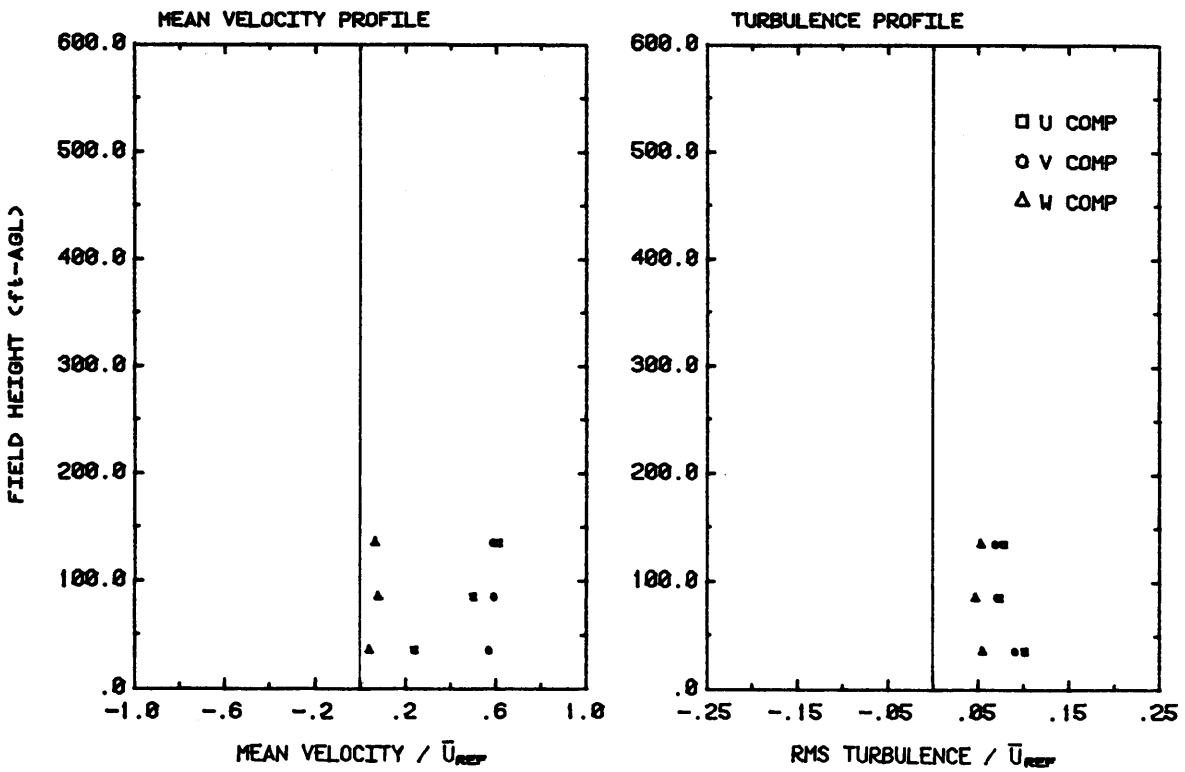


Figure E-72. Normalized mean velocities and turbulence intensity at location N5 for the south southwest (SSW) wind direction.

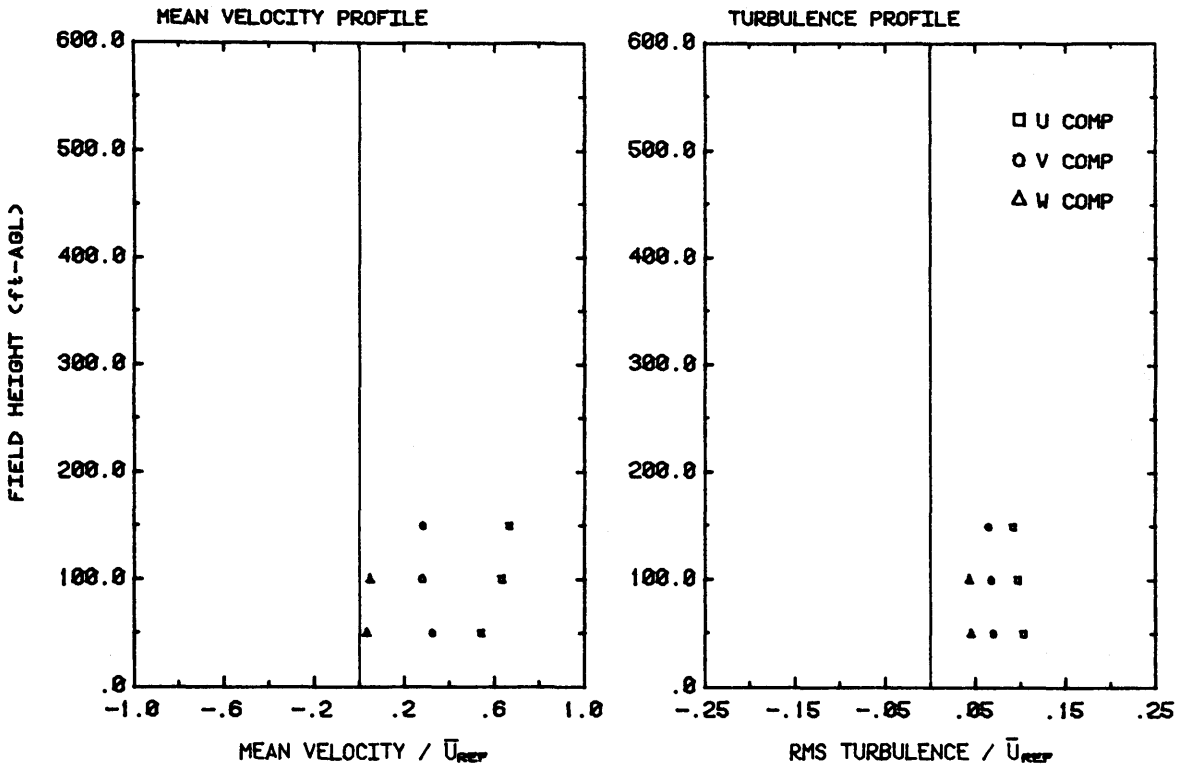


Figure E-73. Normalized mean velocities and turbulence intensity at location 01 for the south southwest (SSW) wind direction.

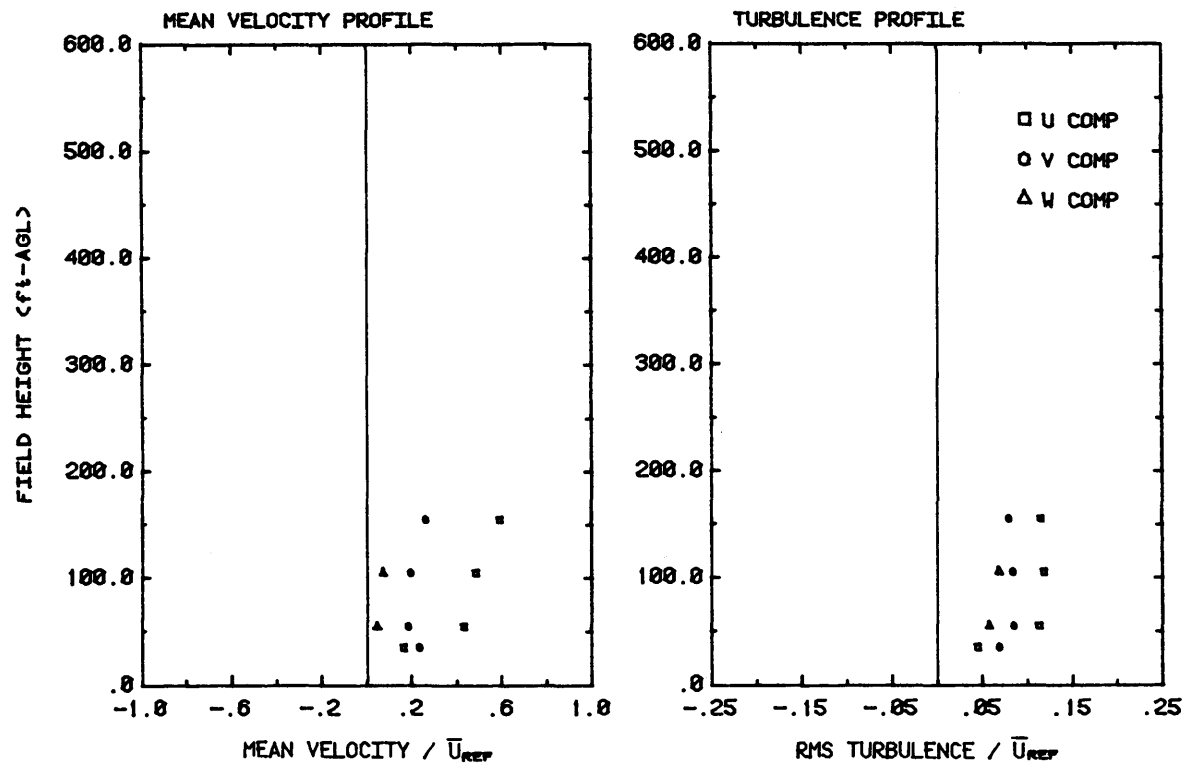


Figure E-74. Normalized mean velocities and turbulence intensity at location 05 for the south southwest (SSW) wind direction.

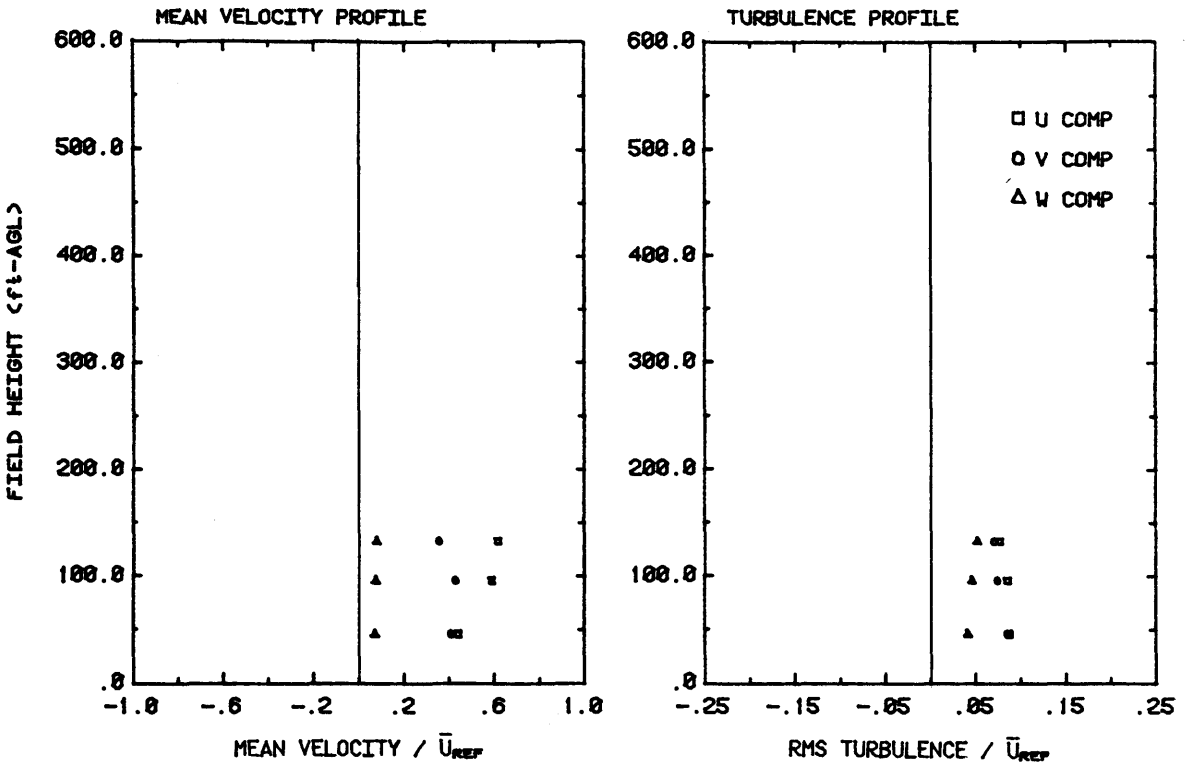


Figure E-75. Normalized mean velocities and turbulence intensity at location P1 for the south southwest (SSW) wind direction.

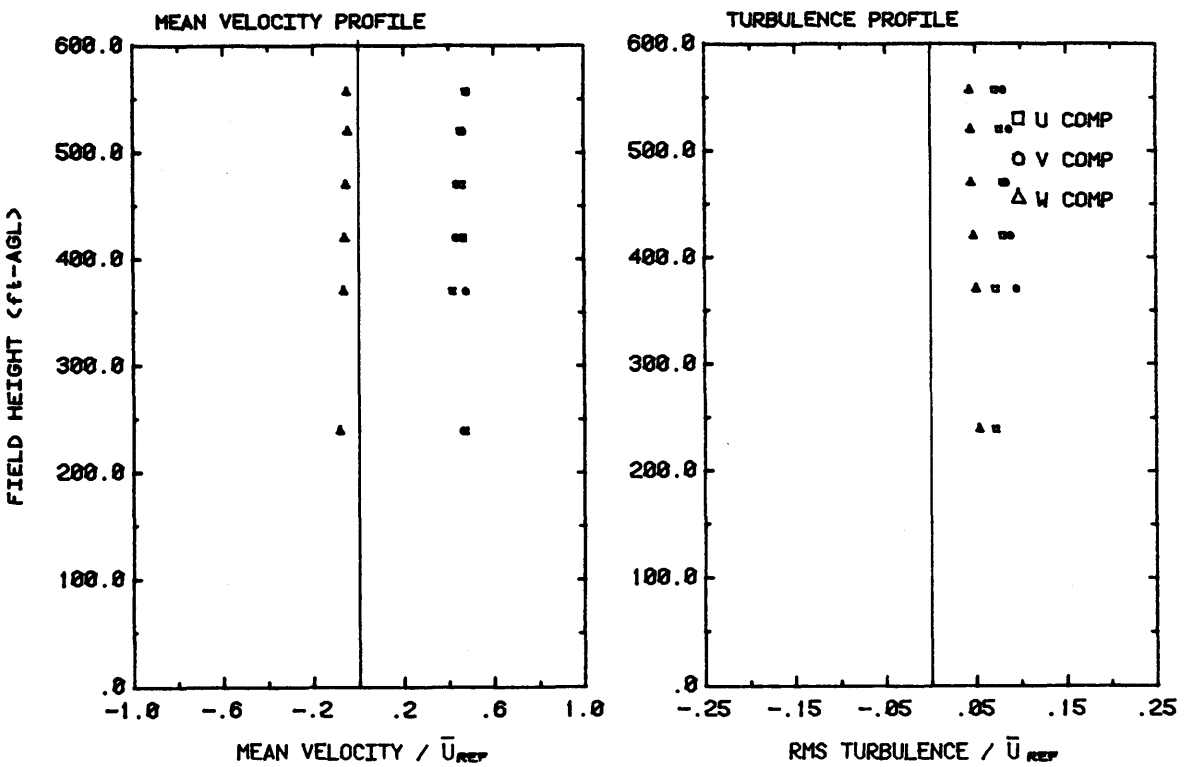


Figure E-76. Normalized mean velocities and turbulence intensity at location P2 for the south southwest (SSW) wind direction.

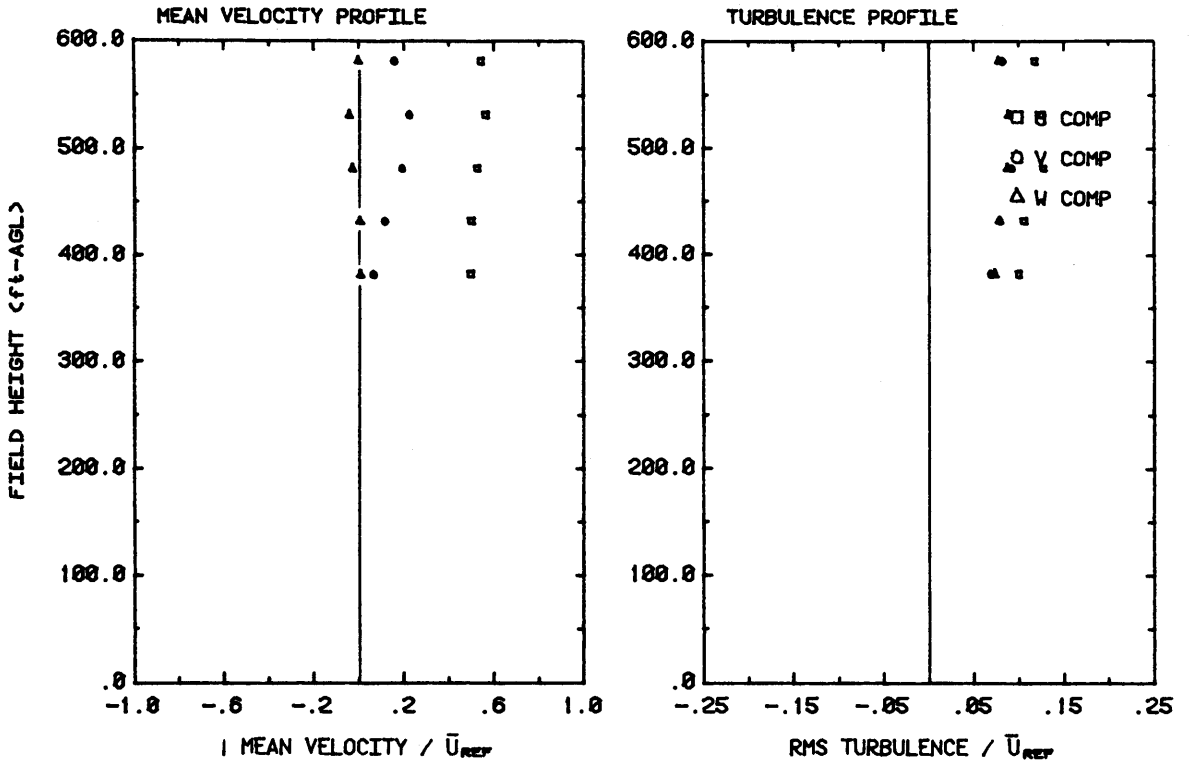


Figure E-77. Normalized mean velocities and turbulence intensity at location P3 for the south southwest (SSW) wind direction.

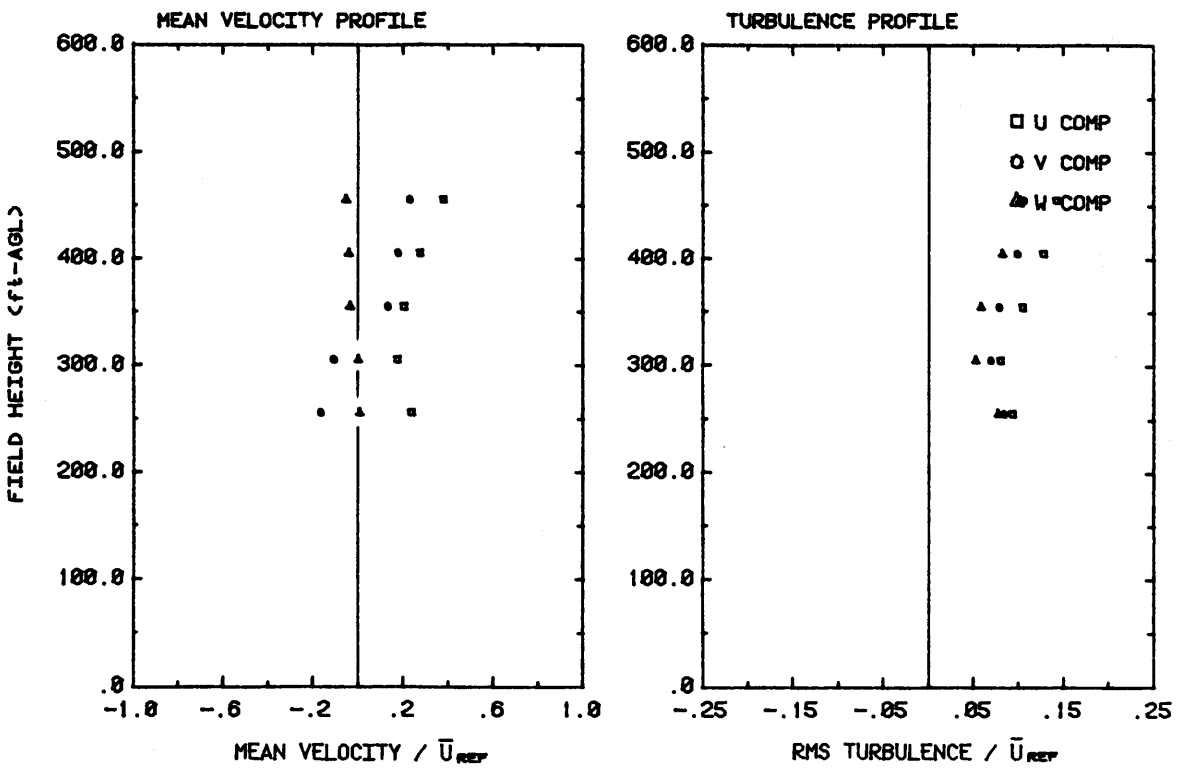


Figure E-78. Normalized mean velocities and turbulence intensity at location P4 for the south southwest (SSW) wind direction.

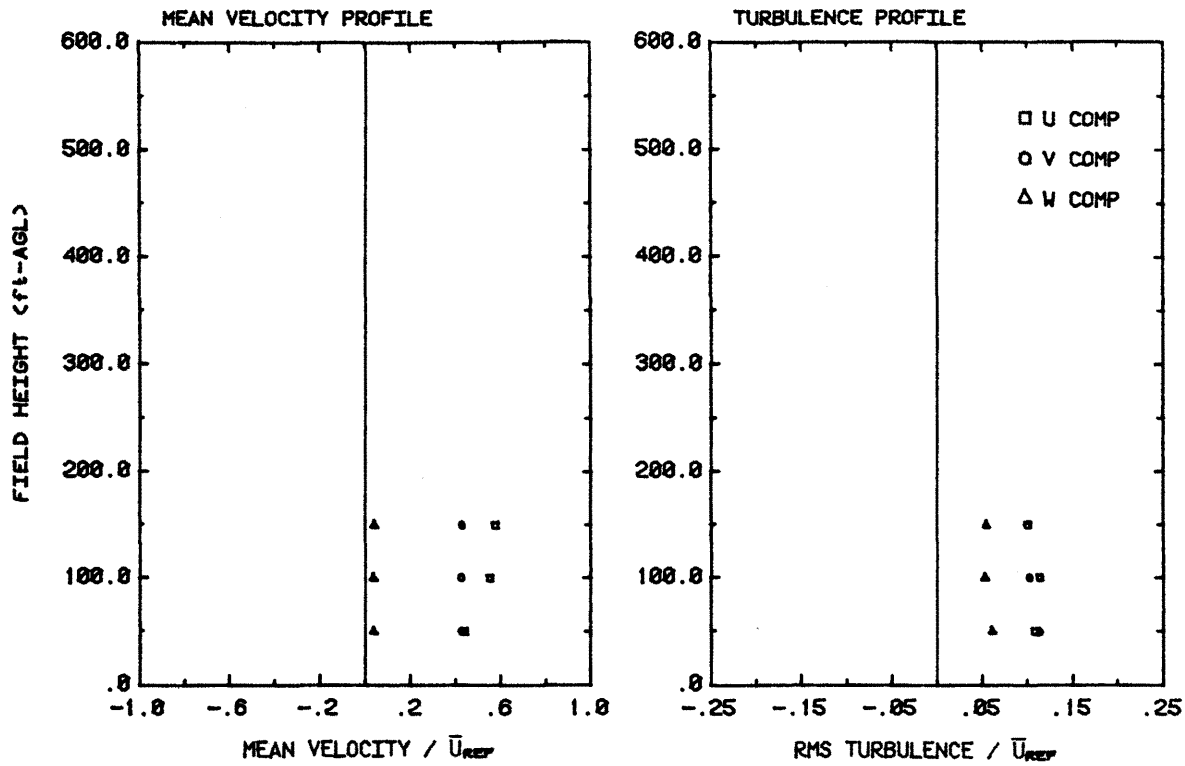


Figure E-79. Normalized mean velocities and turbulence intensity at location P5 for the south southwest (SSW) wind direction.

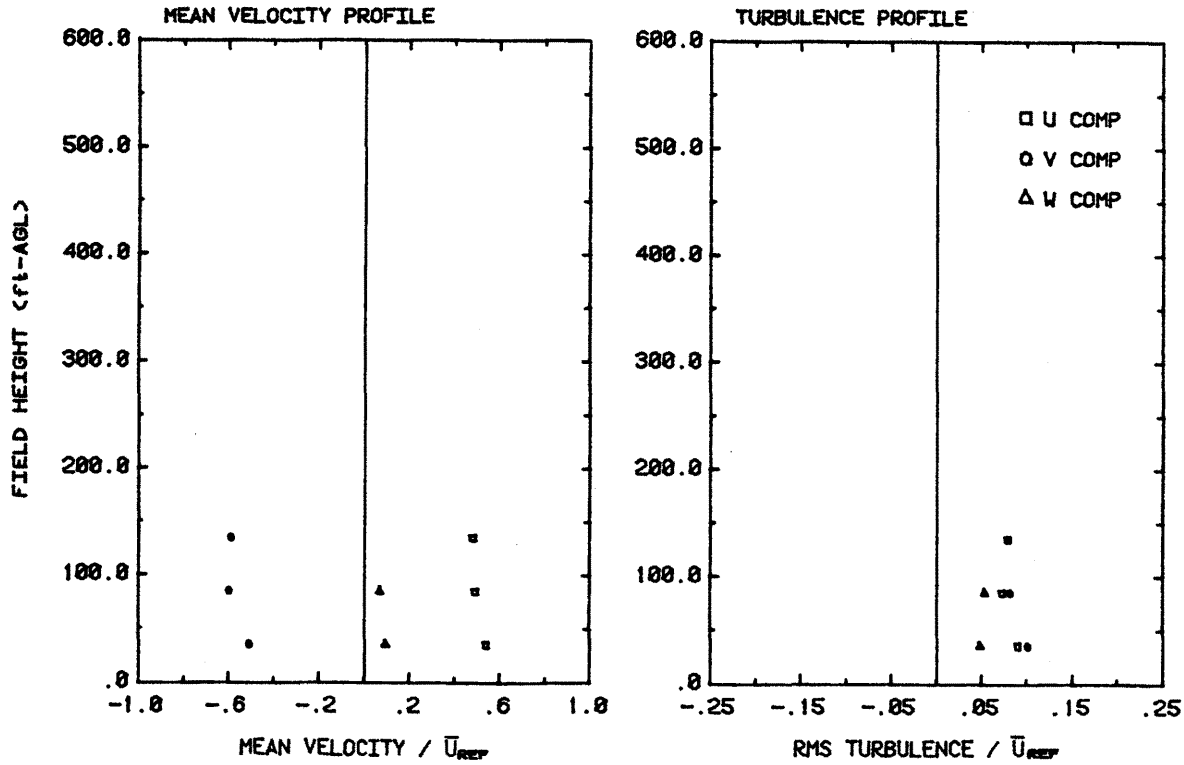


Figure E-80. Normalized mean velocities and turbulence intensity at location Q1 for the south southwest (SSW) wind direction.

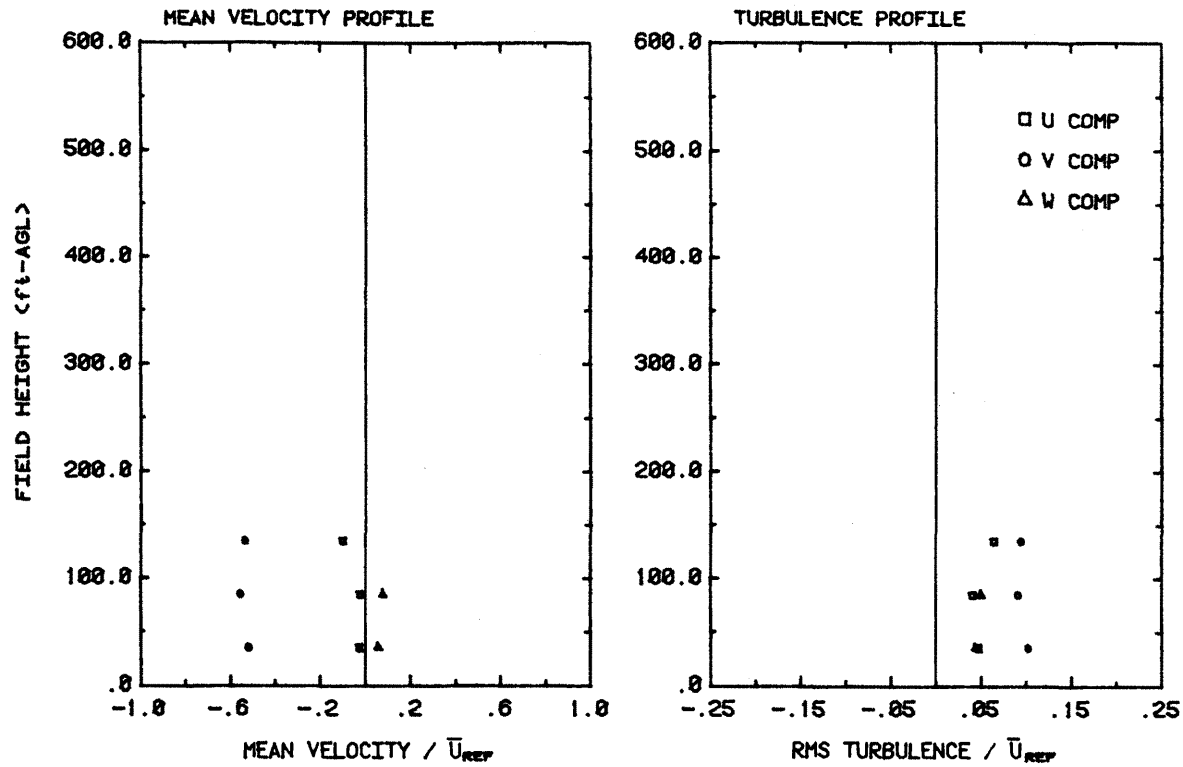


Figure E-81. Normalized mean velocities and turbulence intensity at location Q5 for the south southwest (SSW) wind direction.

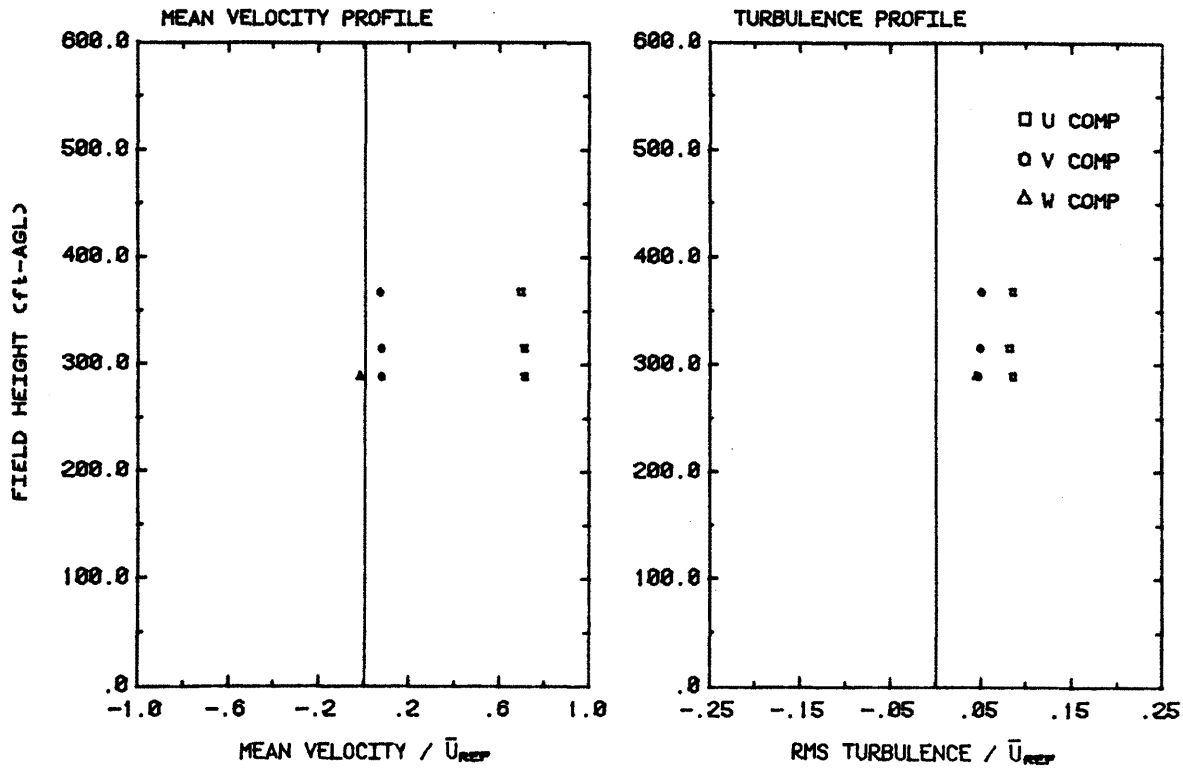


Figure E-82. Normalized mean velocities and turbulence intensity at location A3 for the southwest (SW) wind direction.

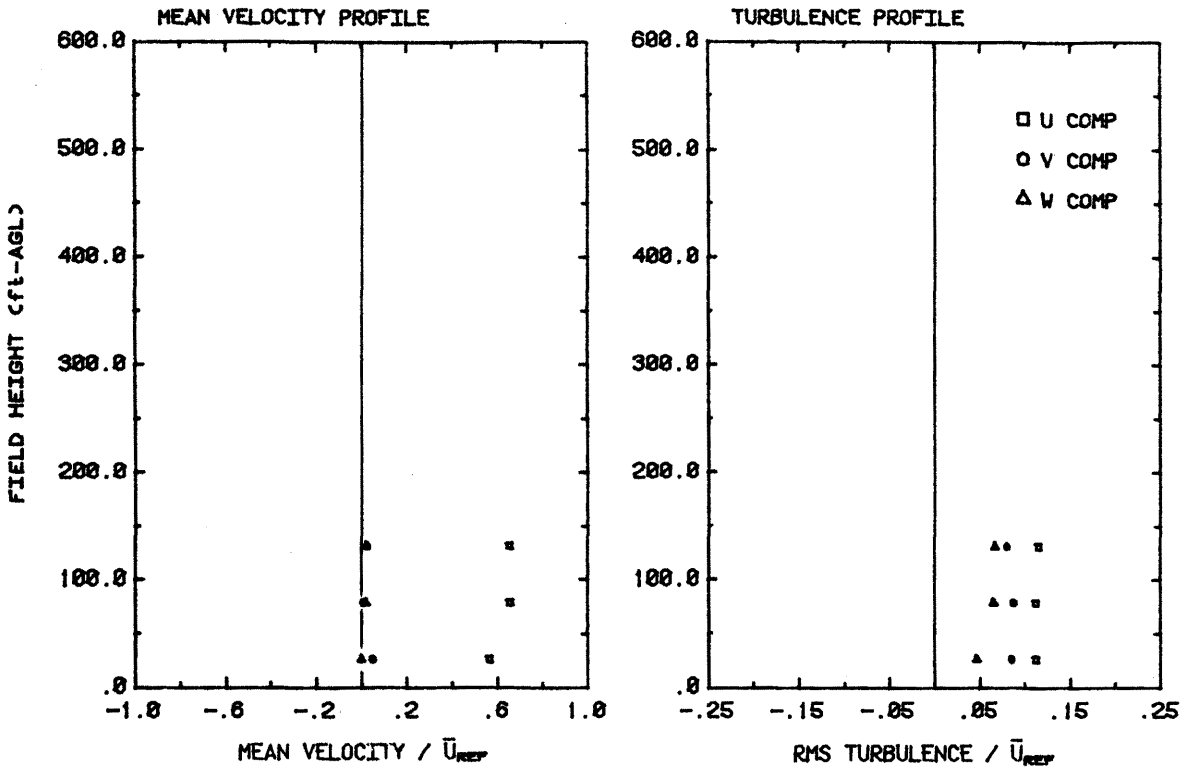


Figure E-83. Normalized mean velocities and turbulence intensity at location A5 for the southwest (SW) wind direction.

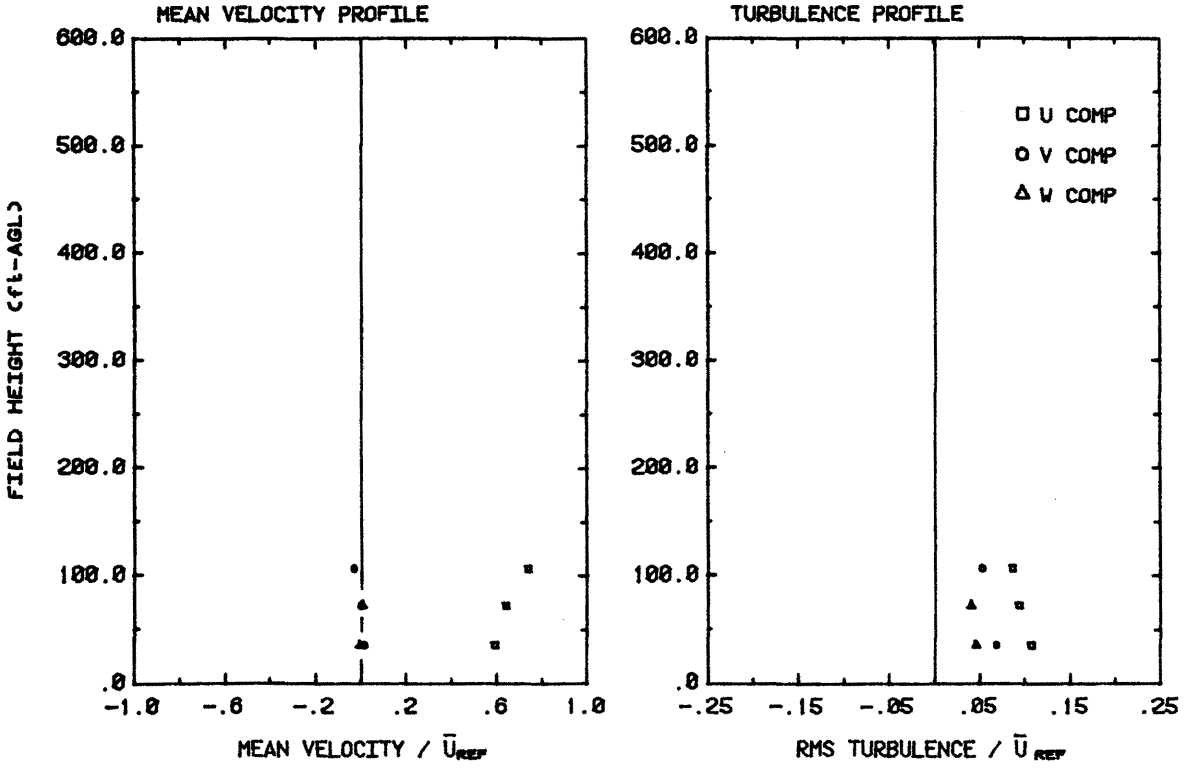


Figure E-84. Normalized mean velocities and turbulence intensity at location K5 for the southwest (SW) wind direction.

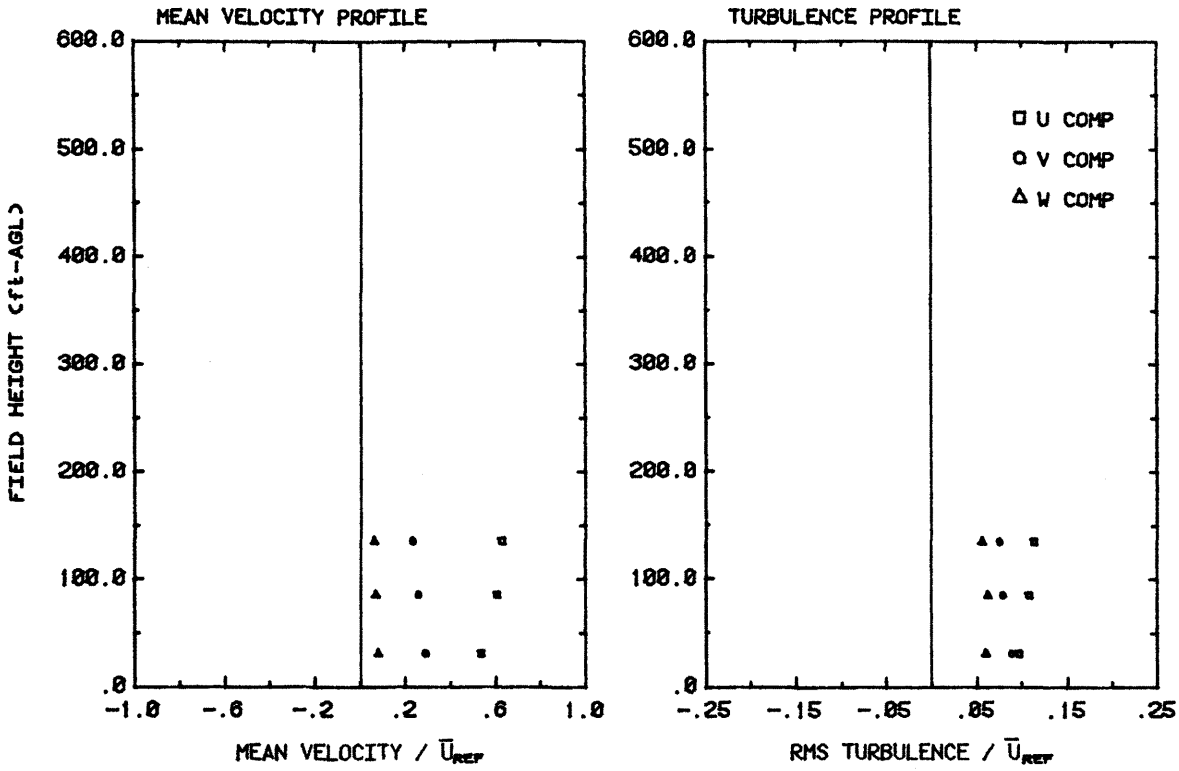


Figure E-85. Normalized mean velocities and turbulence intensity at location N1 for the southwest (SW) wind direction.

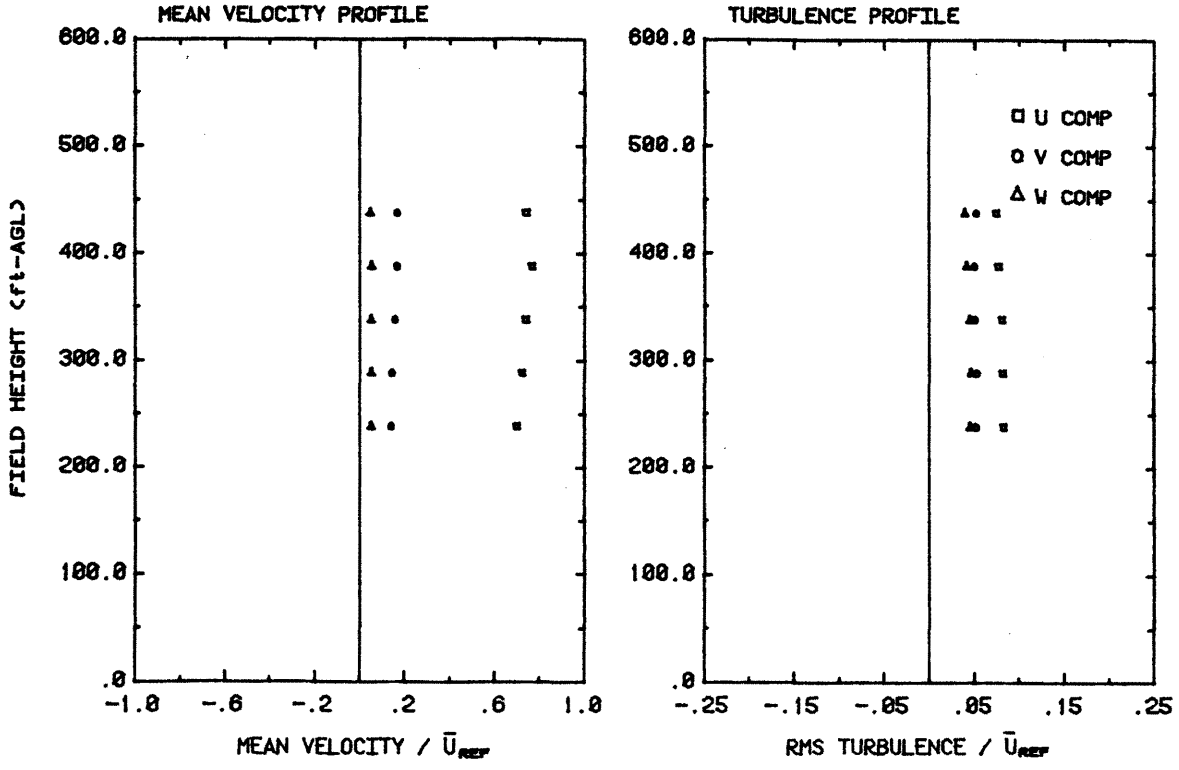


Figure E-86. Normalized mean velocities and turbulence intensity at location N2 for the southwest (SW) wind direction.

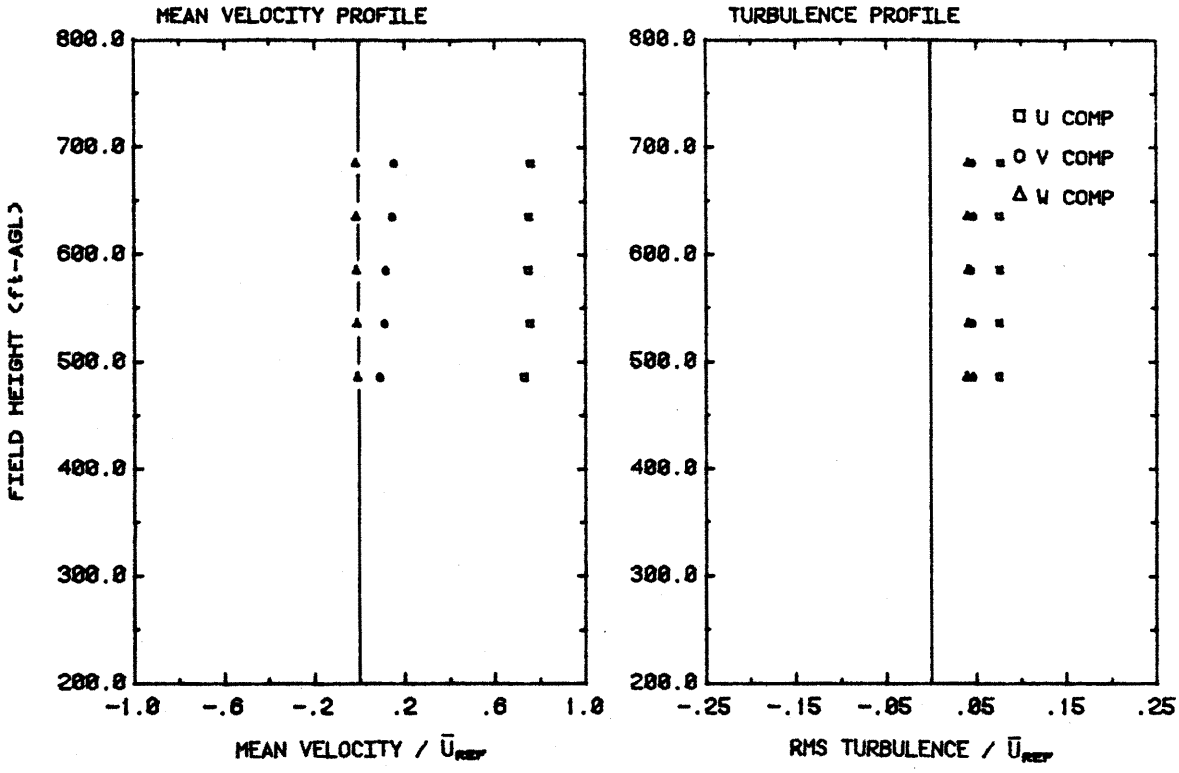


Figure E-87. Normalized mean velocities and turbulence intensity at location N3 for the southwest (SW) wind direction.

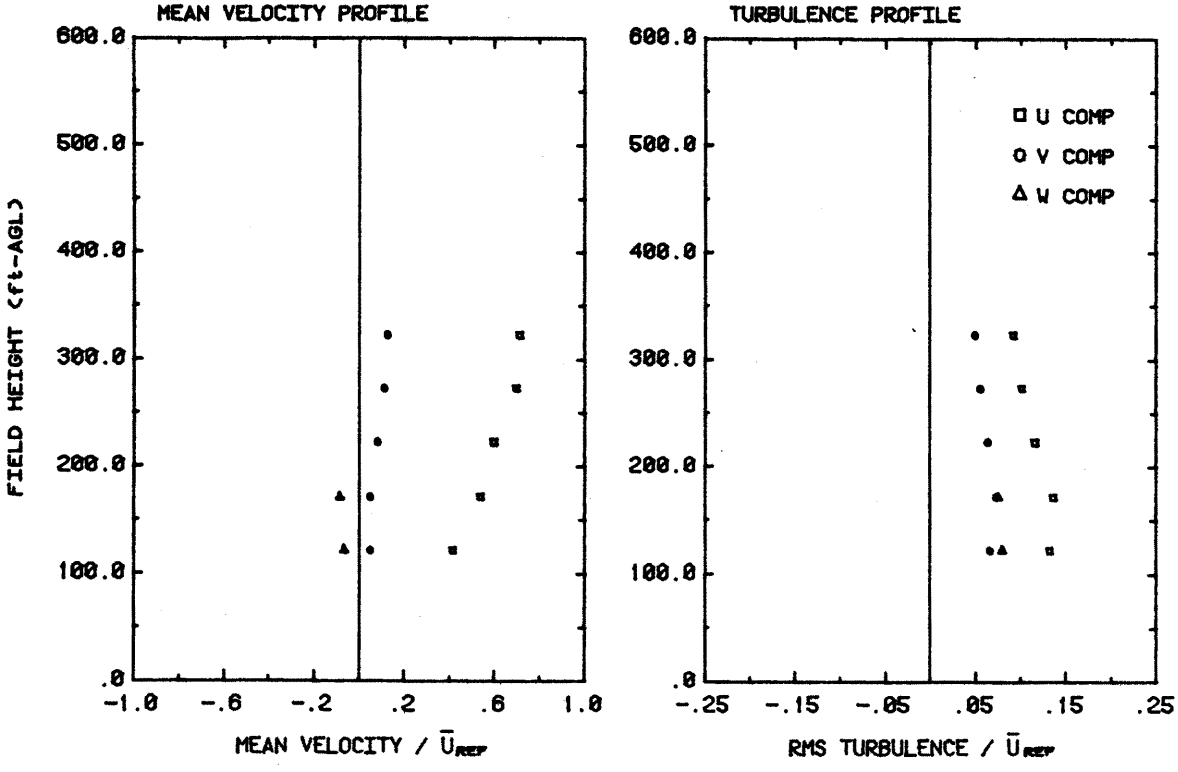


Figure E-88. Normalized mean velocities and turbulence intensity at location N4 for the southwest (SW) wind direction.

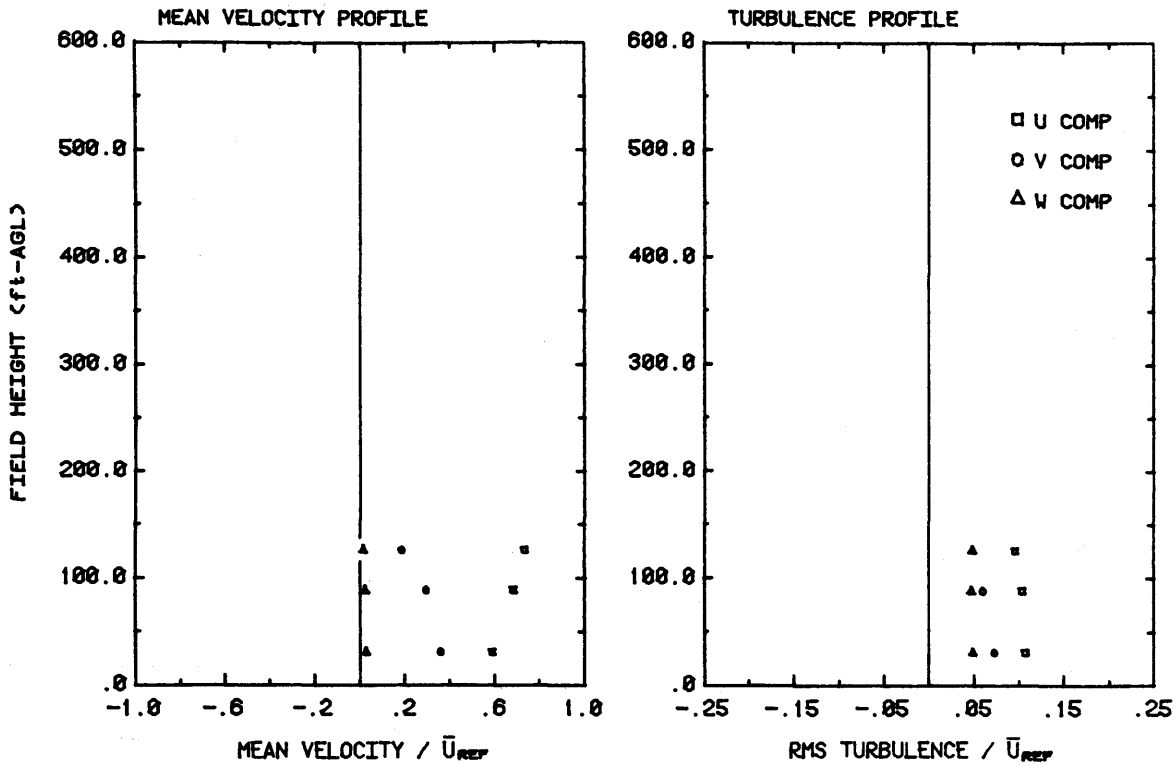


Figure E-89. Normalized mean velocities and turbulence intensity at location N5 for the southwest (SW) wind direction.

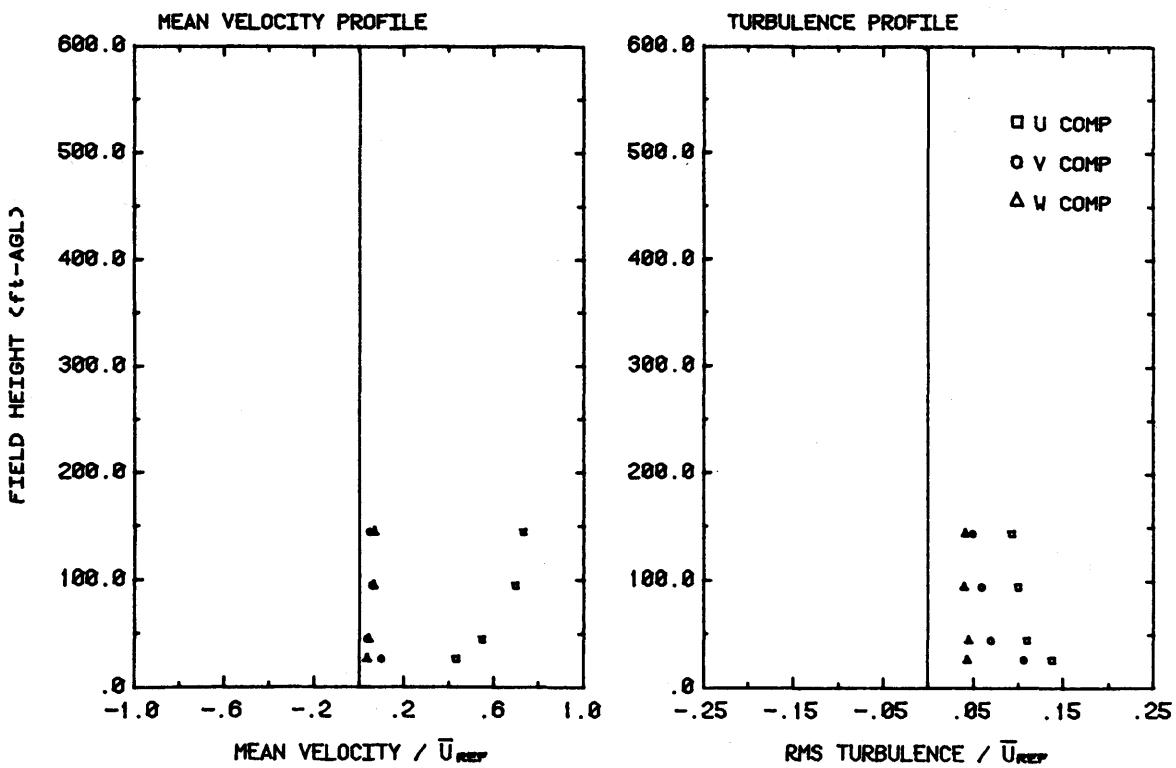


Figure E-90. Normalized mean velocities and turbulence intensity at location P1 for the southwest (SW) wind direction.

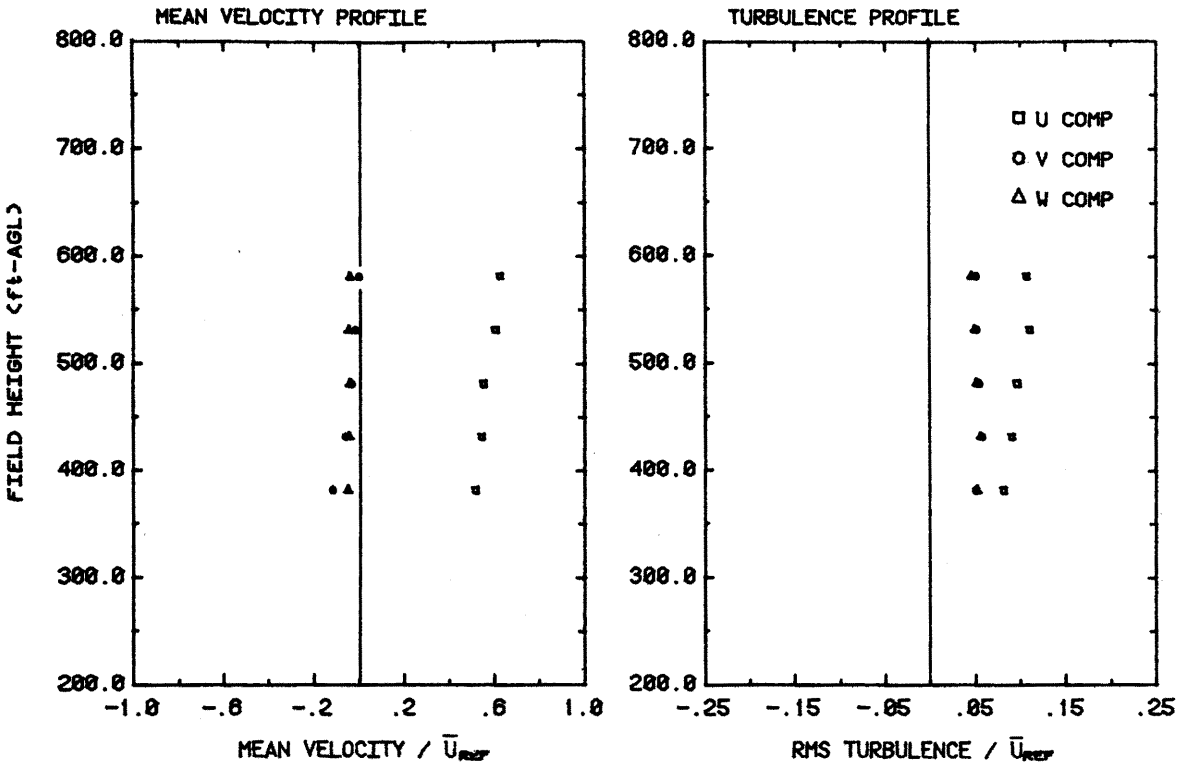


Figure E-91. Normalized mean velocities and turbulence intensity at location P3 for the southwest (SW) wind direction.

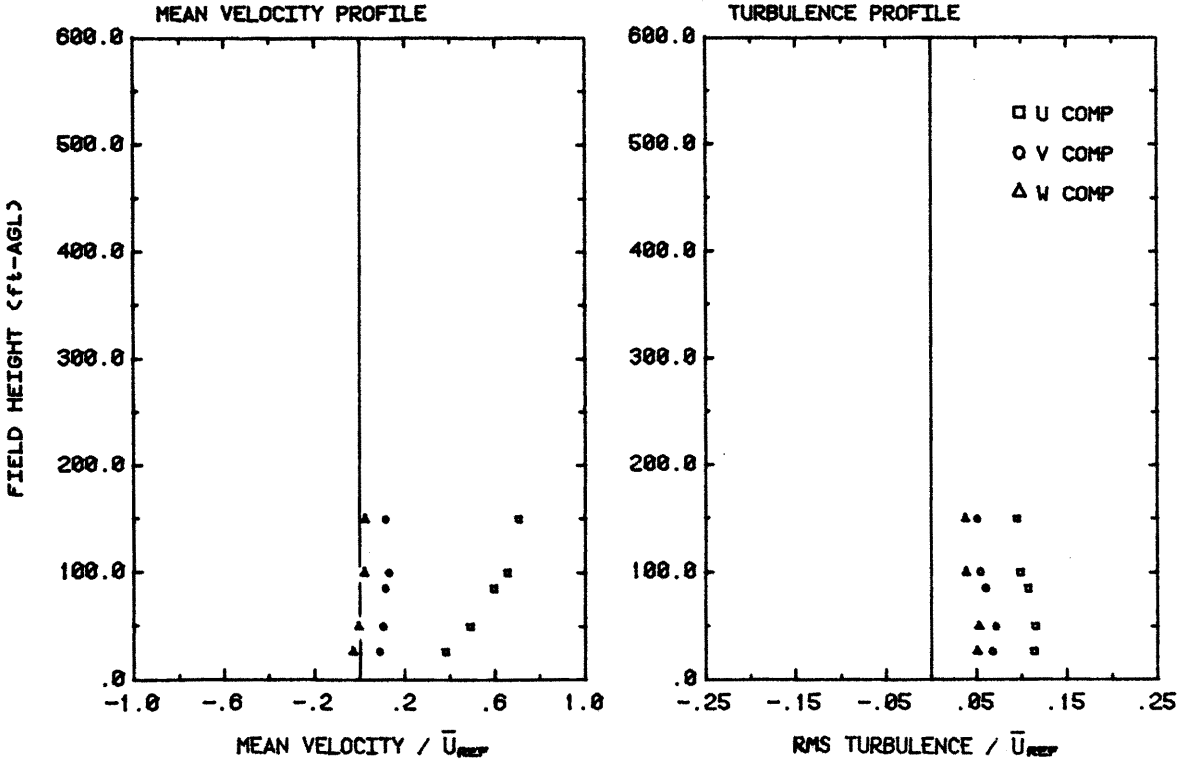


Figure E-92. Normalized mean velocities and turbulence intensity at location P5 for the southwest (SW) wind direction.

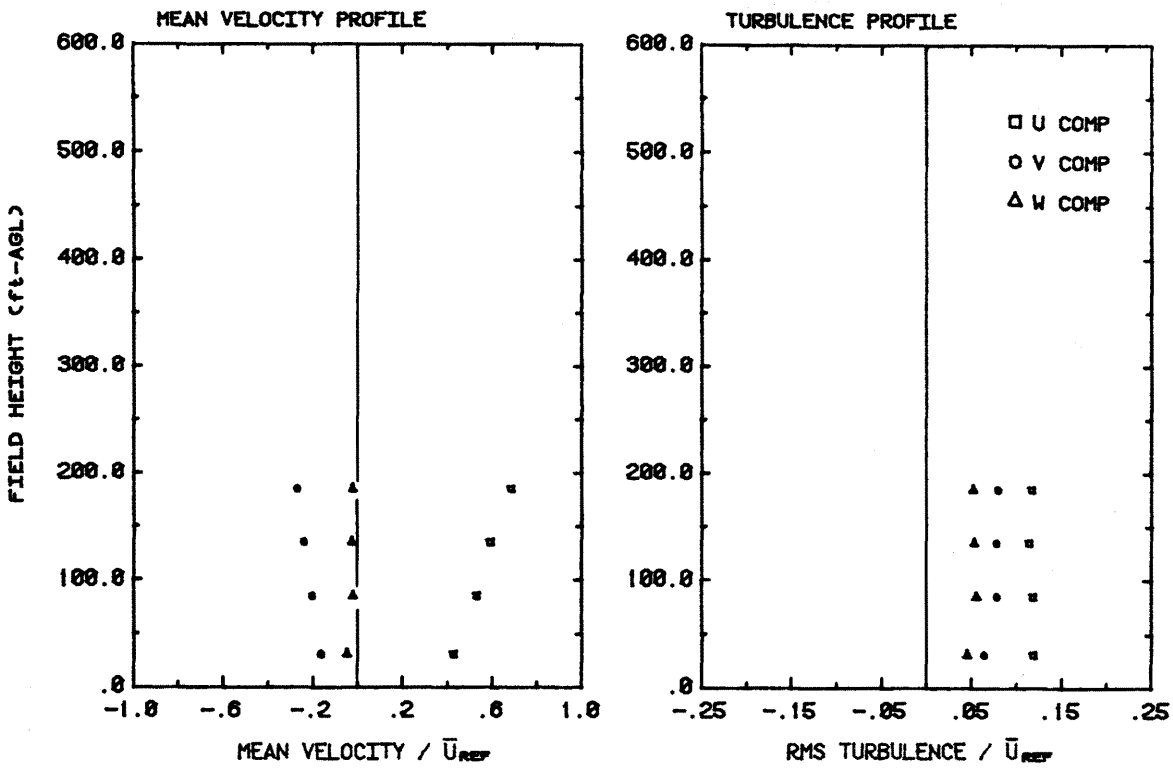


Figure E-93. Normalized mean velocities and turbulence intensity at location A1 for the west southwest (WSW) wind direction.

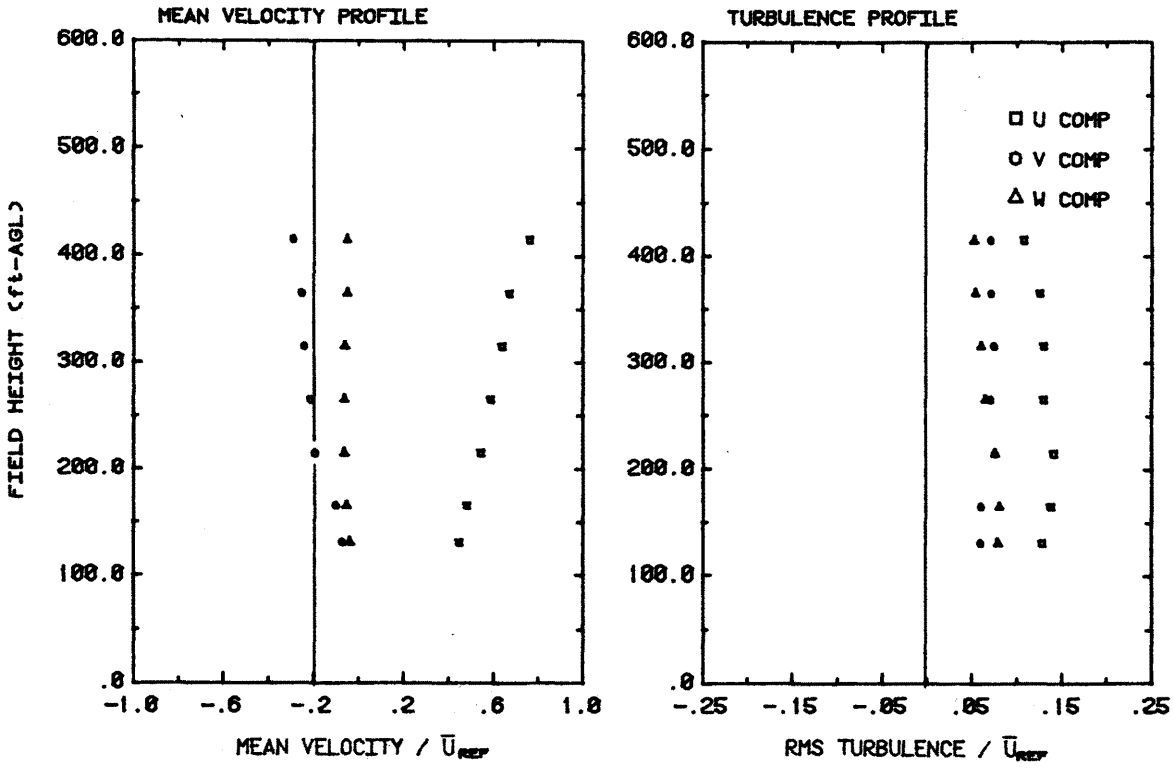


Figure E-94. Normalized mean velocities and turbulence intensity at location A2 for the west southwest (WSW) wind direction.

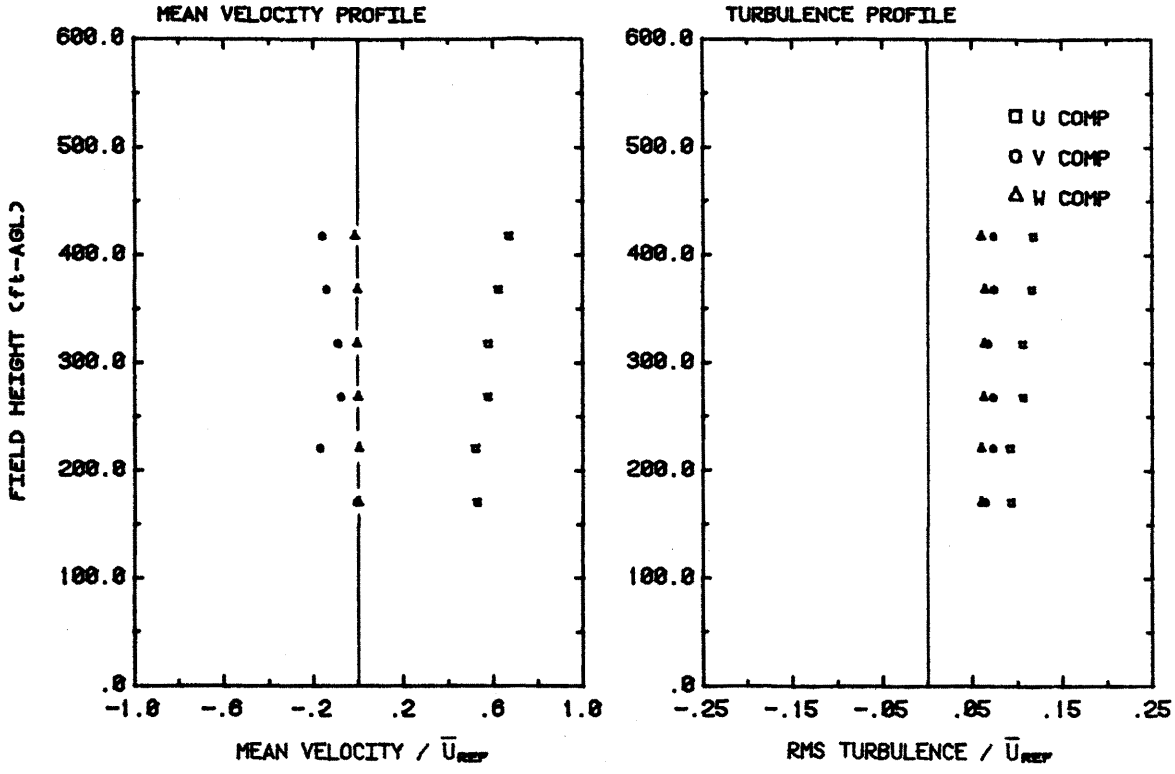


Figure E-95. Normalized mean velocities and turbulence intensity at location A3 for the west southwest (WSW) wind direction.

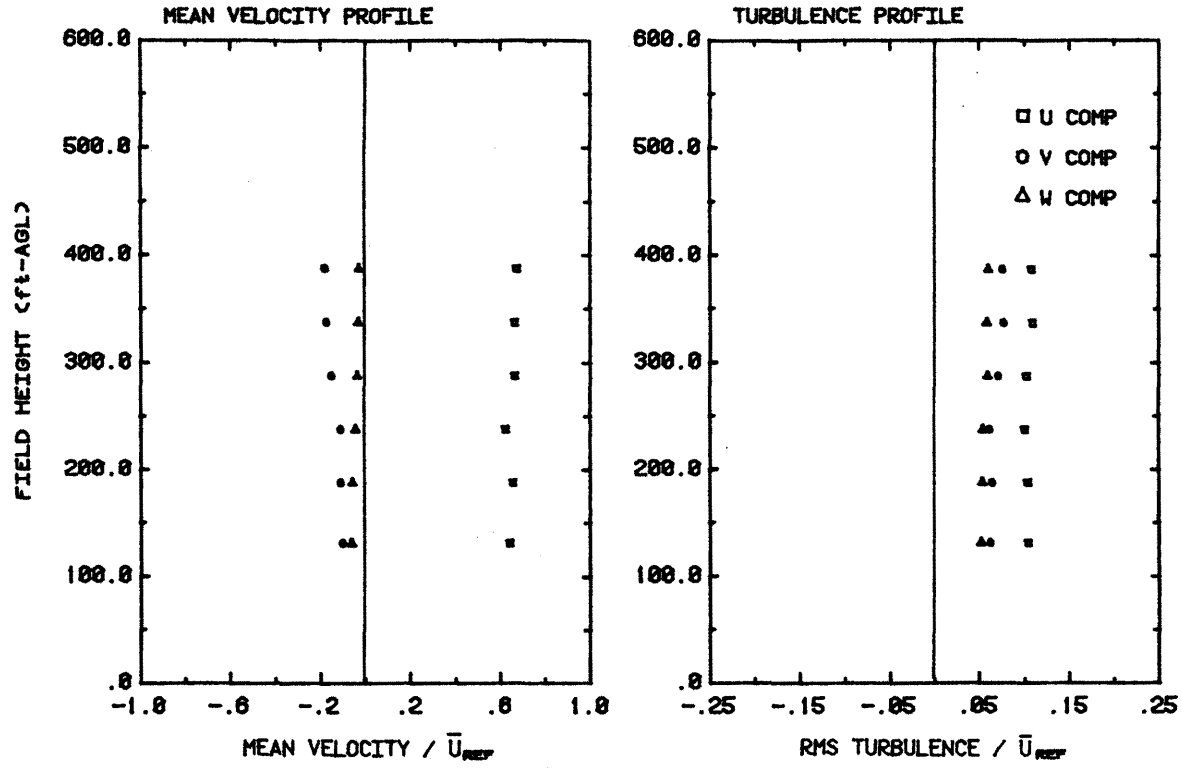


Figure E-96. Normalized mean velocities and turbulence intensity at location A4 for the west southwest (WSW) wind direction.

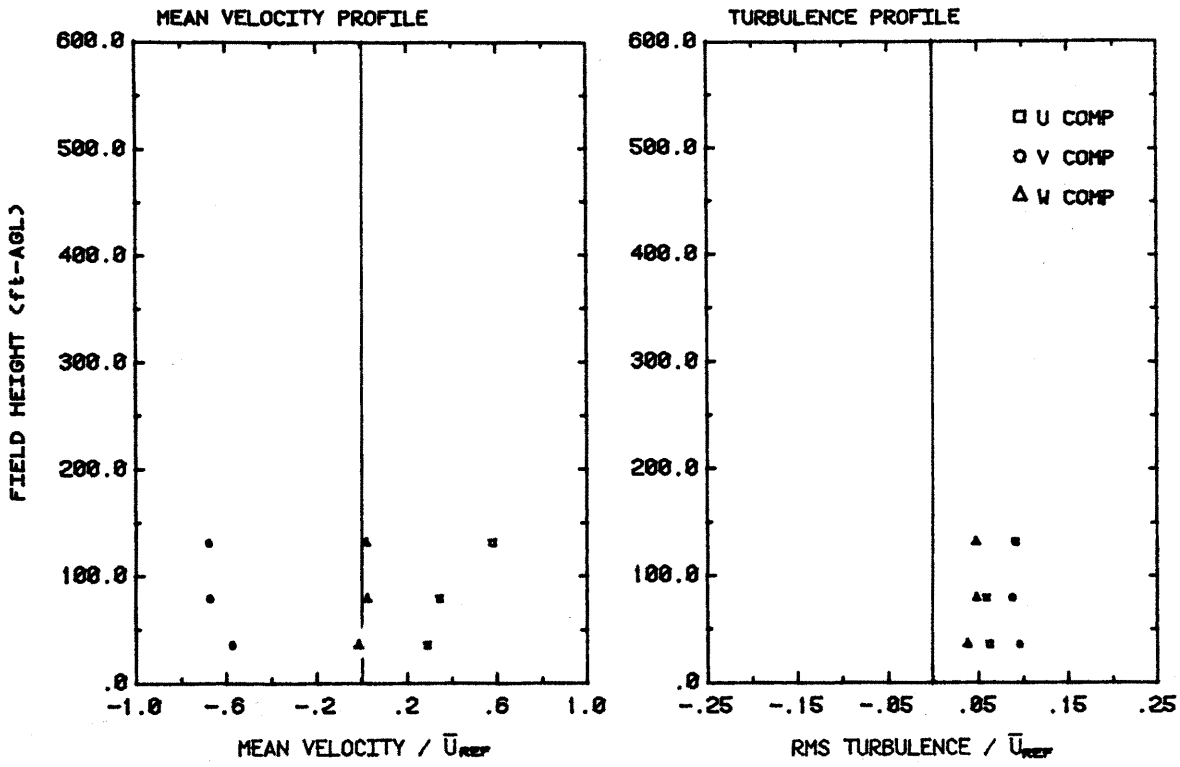


Figure E-97. Normalized mean velocities and turbulence intensity at location A5 for the west southwest (WSW) wind direction.

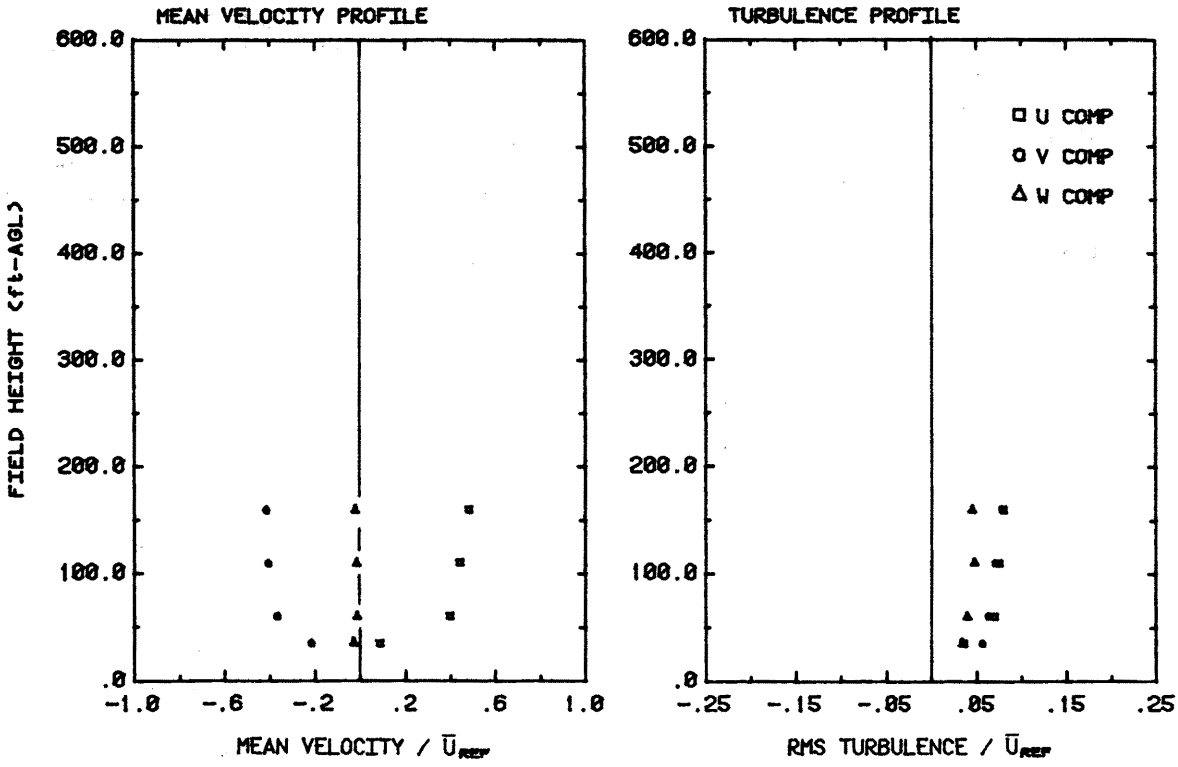


Figure E-98. Normalized mean velocities and turbulence intensity at location B1 for the west southwest (WSW) wind direction.

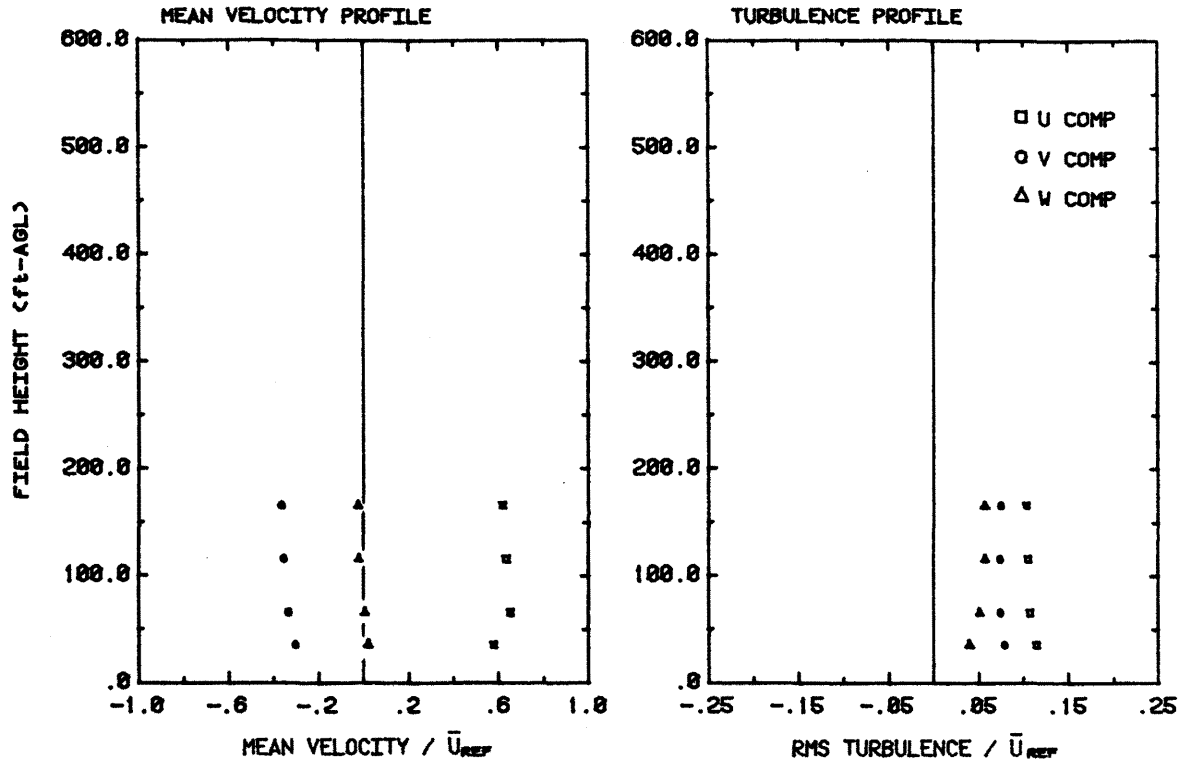


Figure E-99. Normalized mean velocities and turbulence intensity at location B5 for the west southwest (WSW) wind direction.

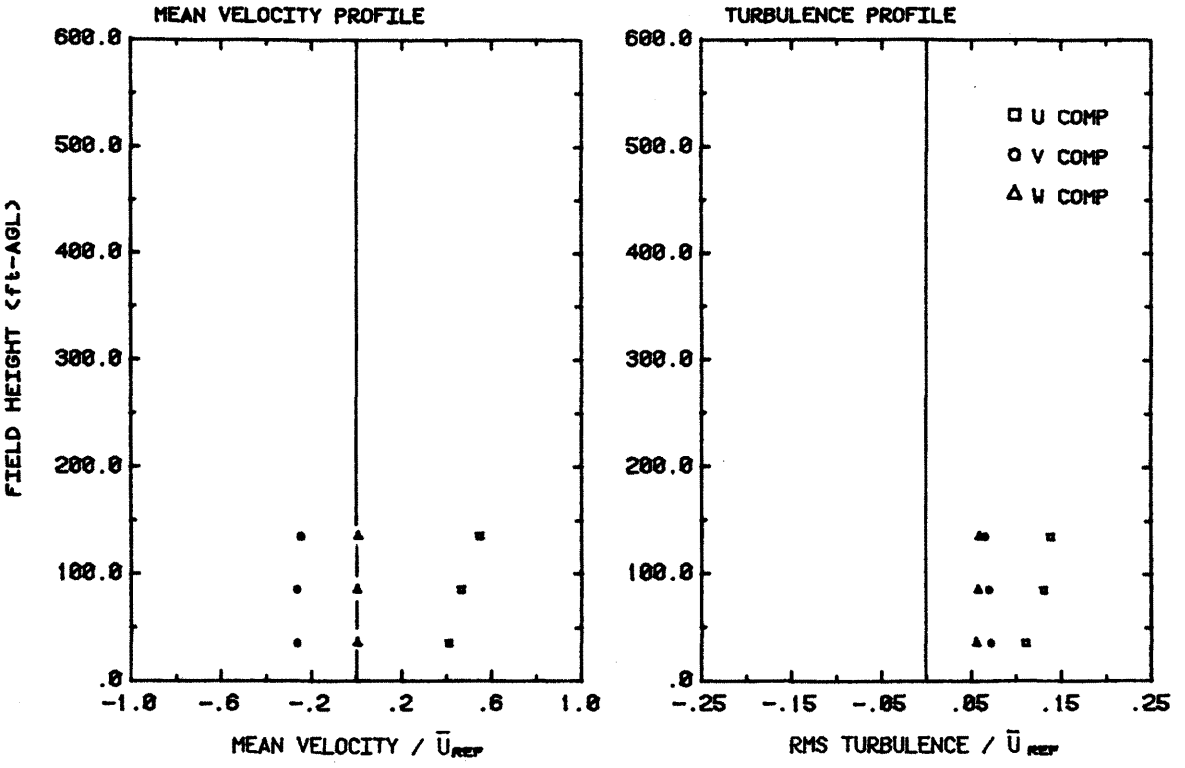


Figure E-100. Normalized mean velocities and turbulence intensity at location C1 for the west southwest (WSW) wind direction.

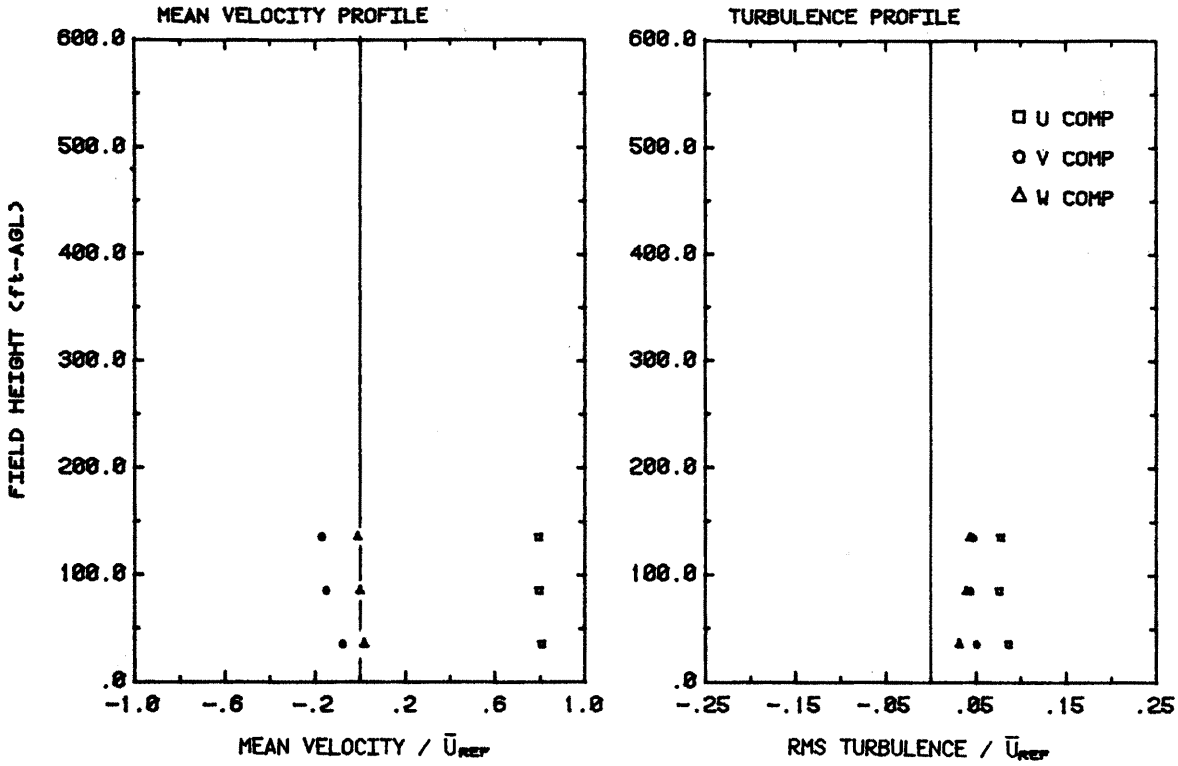


Figure E-101. Normalized mean velocities and turbulence intensity at location C5 for the west southwest (WSW) wind direction.

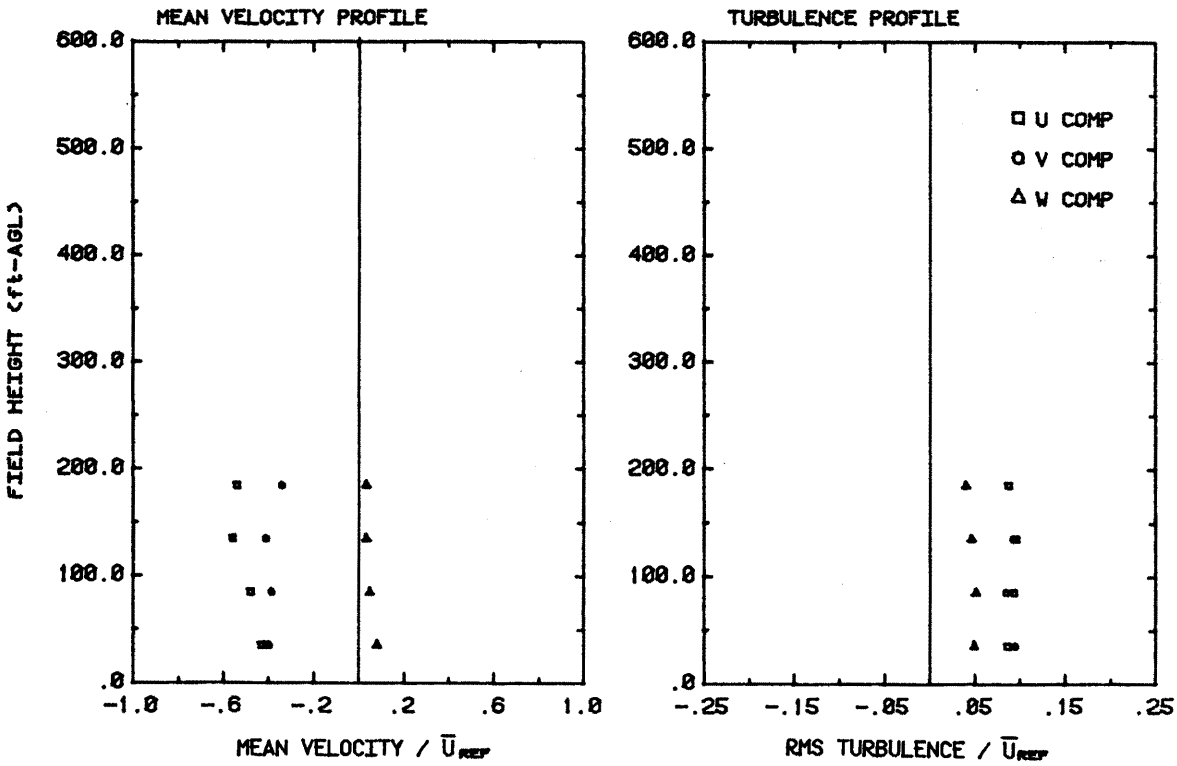


Figure E-102. Normalized mean velocities and turbulence intensity at location F1 for the west southwest (WSW) wind direction.

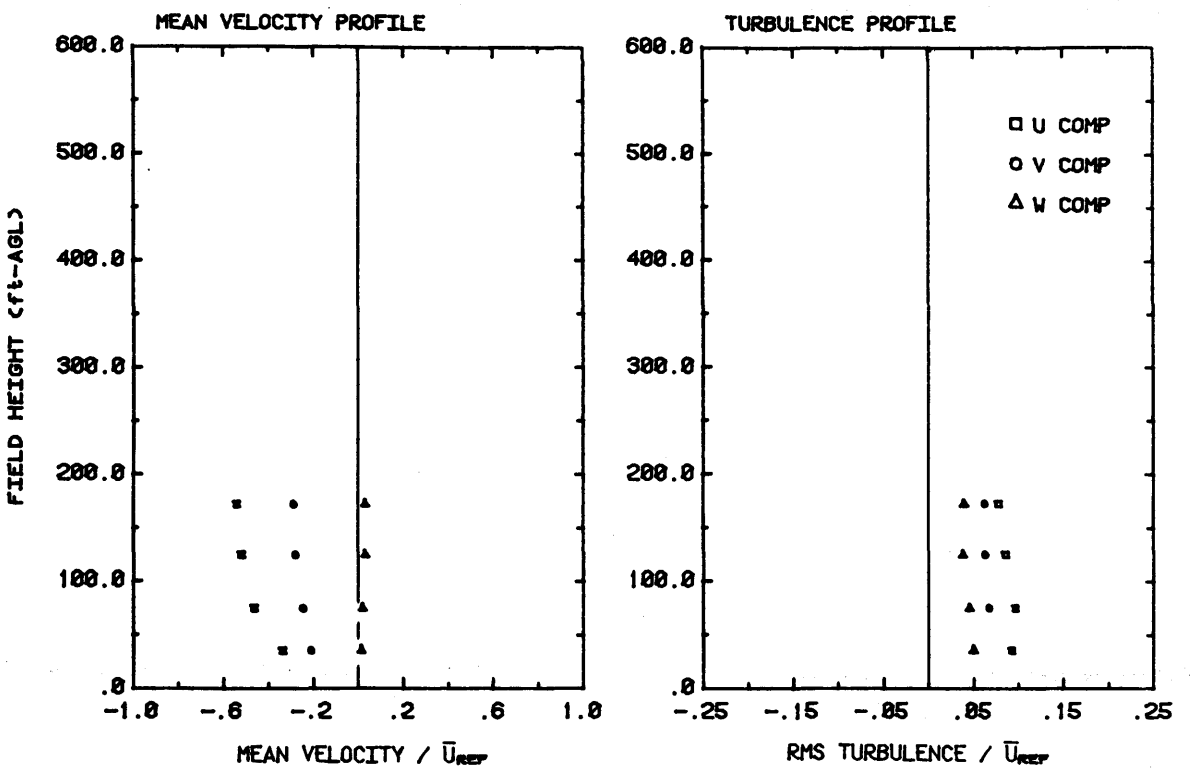


Figure E-103. Normalized mean velocities and turbulence intensity at location F5 for the west southwest (WSW) wind direction.

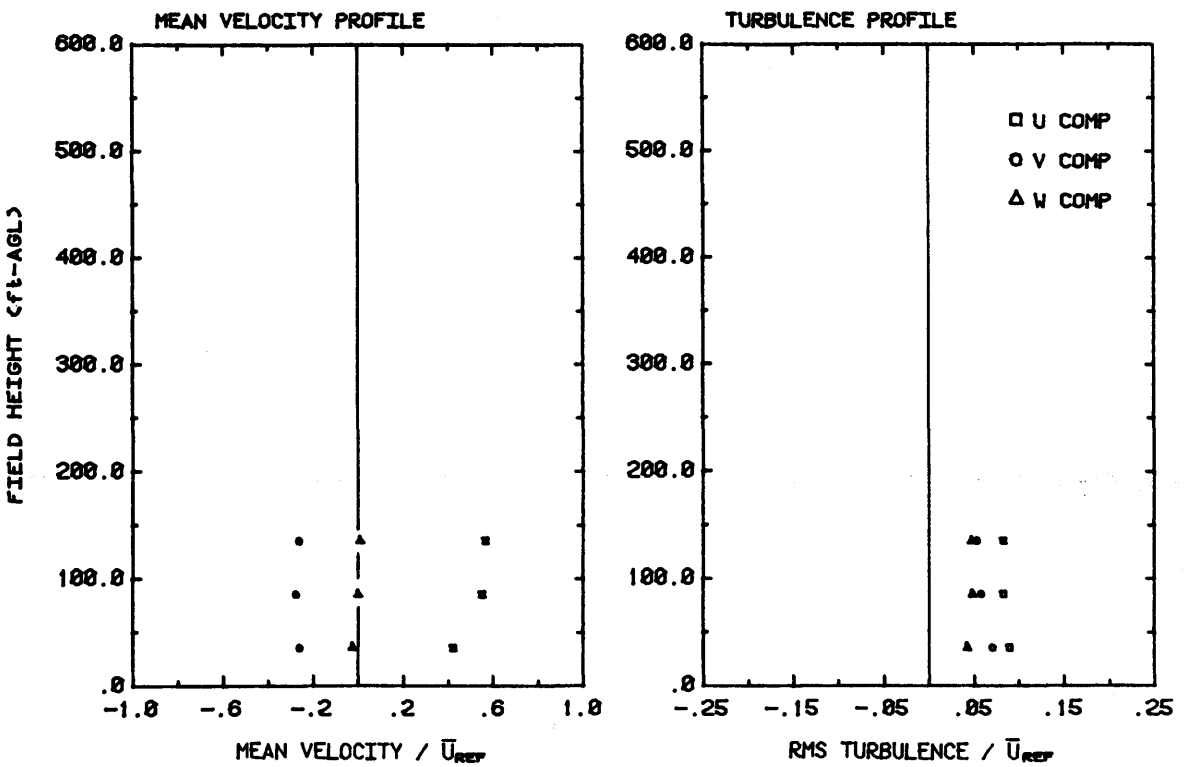


Figure E-104. Normalized mean velocities and turbulence intensity at location G1 for the west southwest (WSW) wind direction.

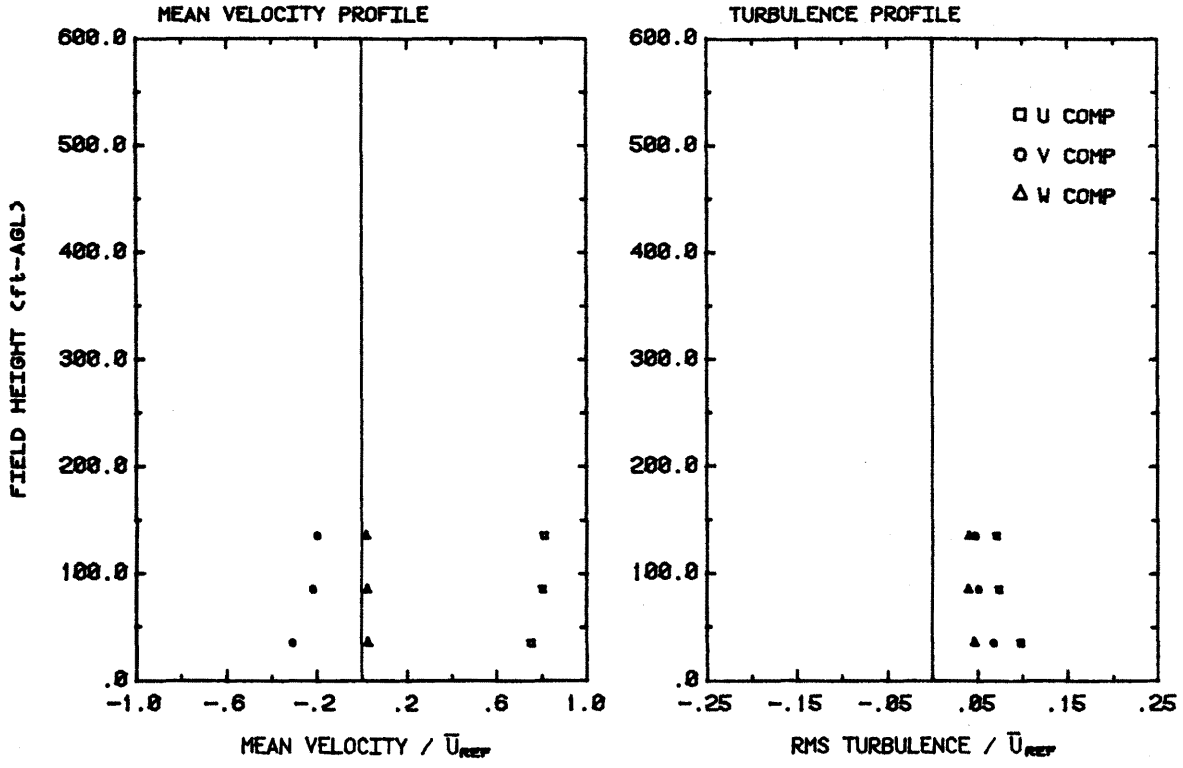


Figure E-105. Normalized mean velocities and turbulence intensity at location G5 for the west southwest (WSW) wind direction.

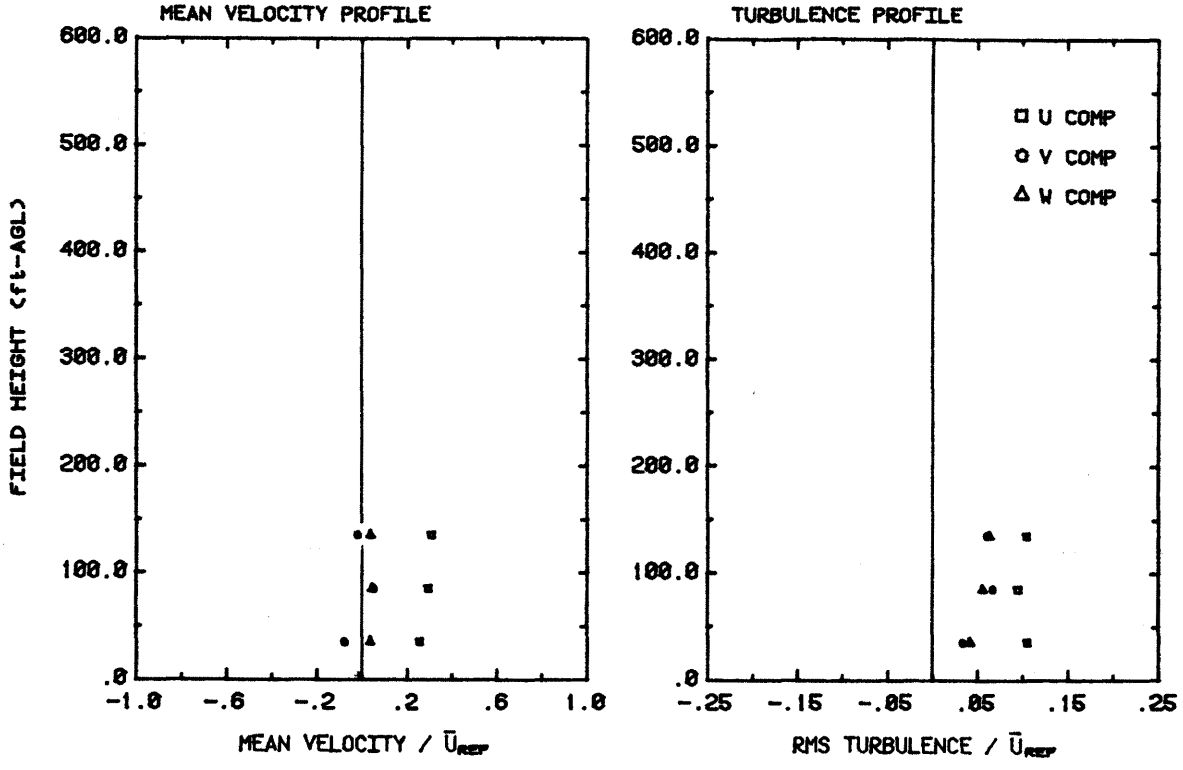


Figure E-106. Normalized mean velocities and turbulence intensity at location H1 for the west southwest (WSW) wind direction.

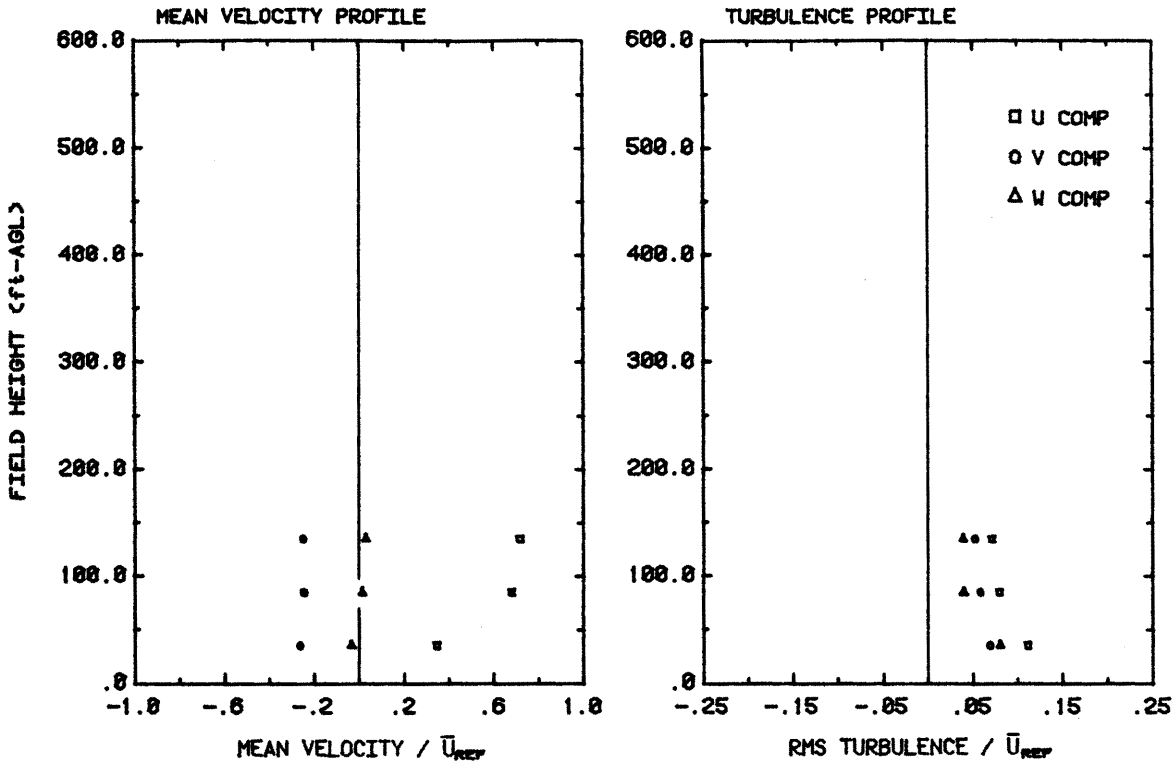


Figure E-107. Normalized mean velocities and turbulence intensity at location H5 for the west southwest (WSW) wind direction.

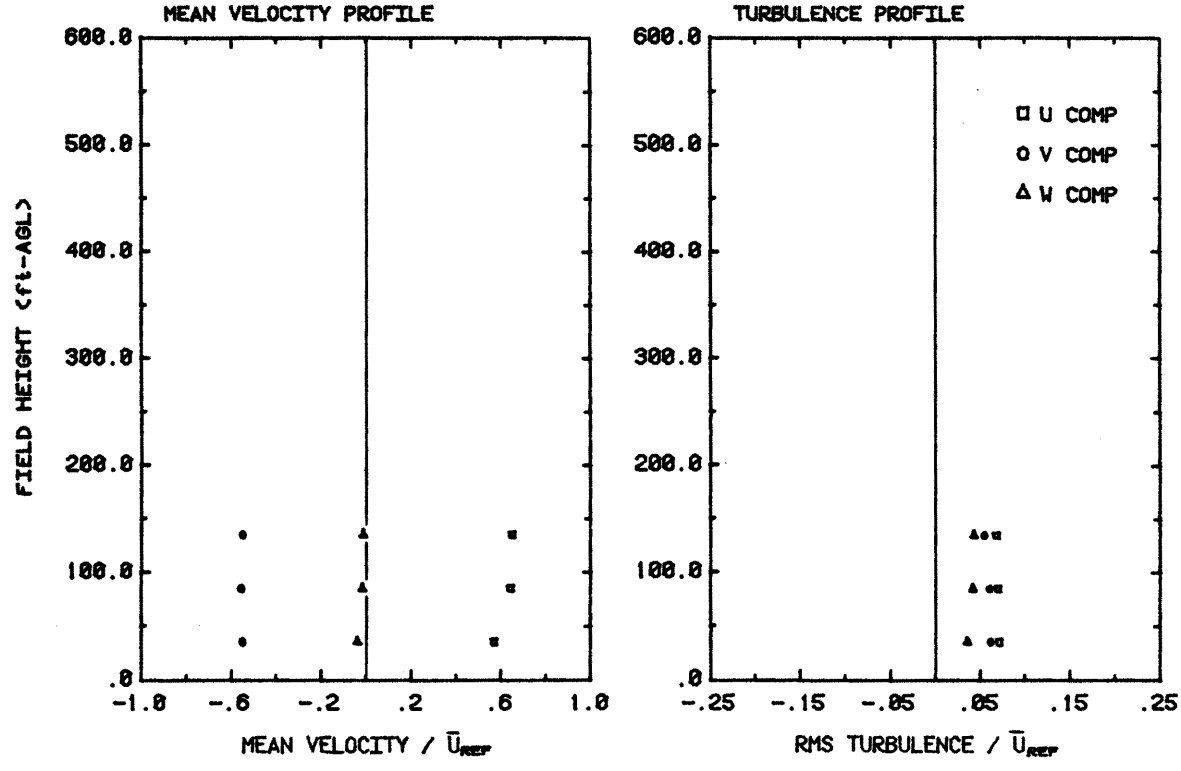


Figure E-108. Normalized mean velocities and turbulence intensity at location I1 for the west southwest (WSW) wind direction.

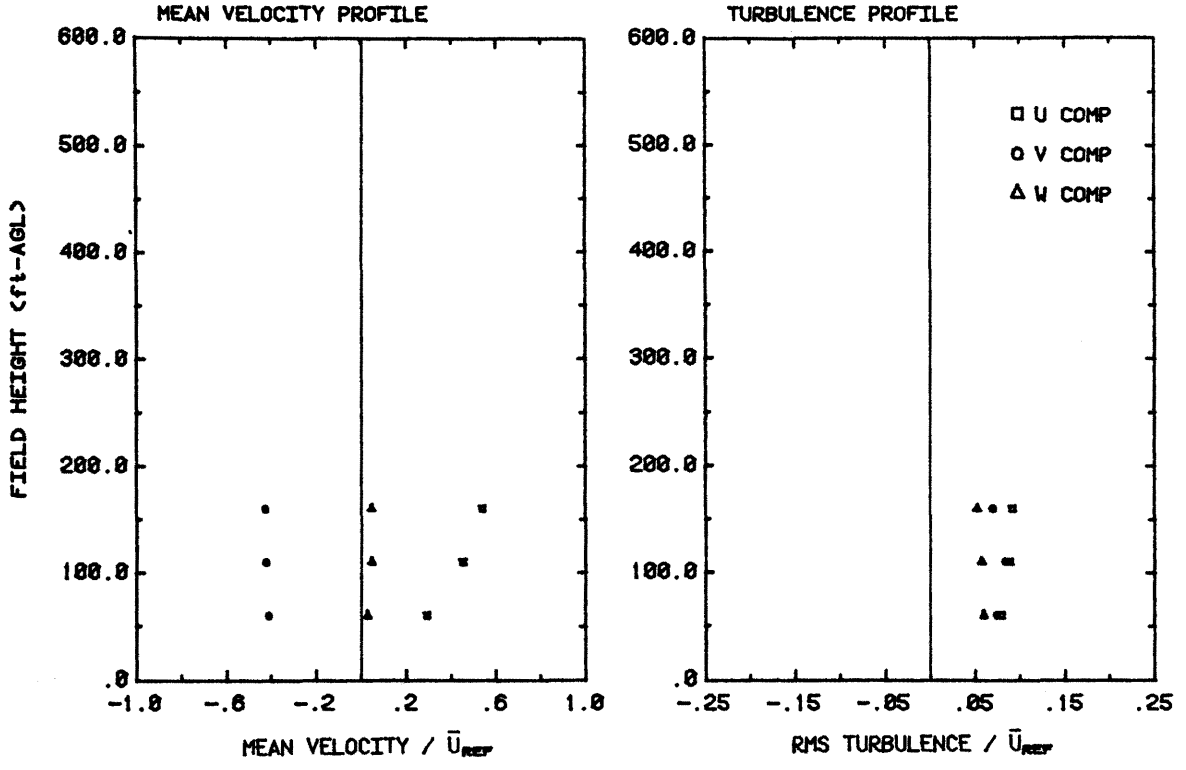


Figure E-109. Normalized mean velocities and turbulence intensity at location I5 for the west southwest (WSW) wind direction.

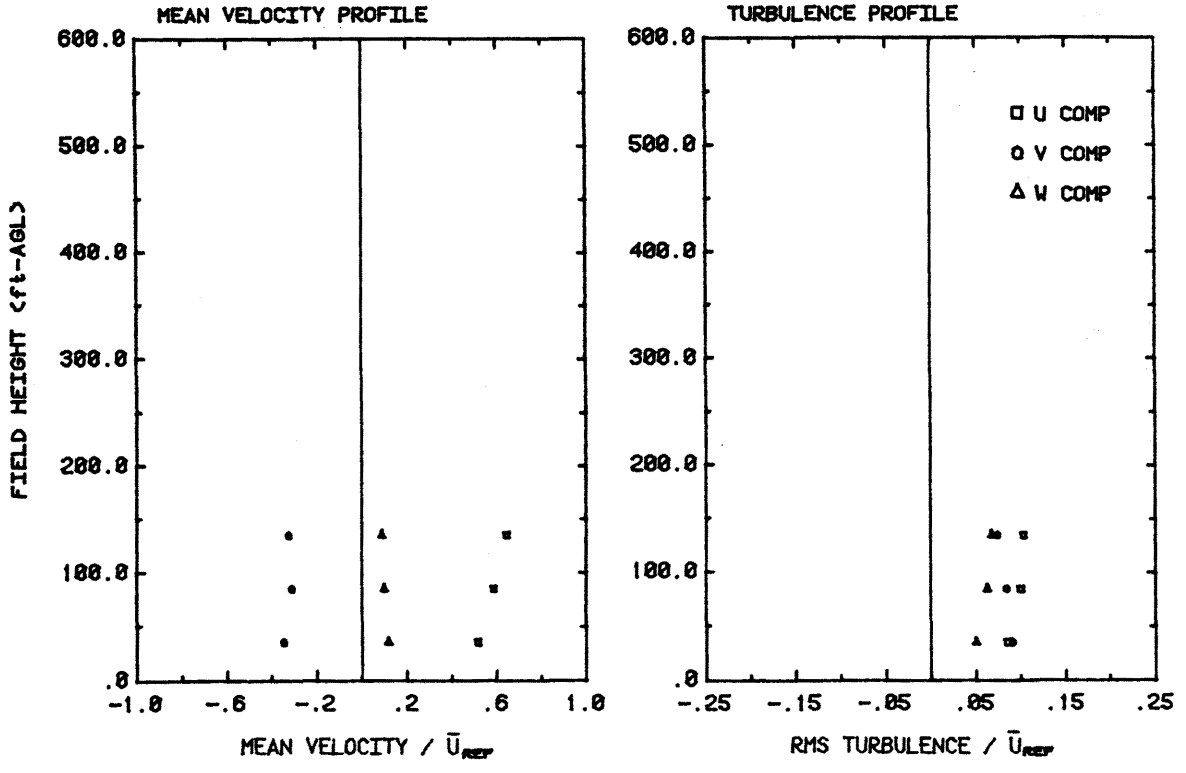


Figure E-110. Normalized mean velocities and turbulence intensity at location J5 for the west southwest (WSW) wind direction.

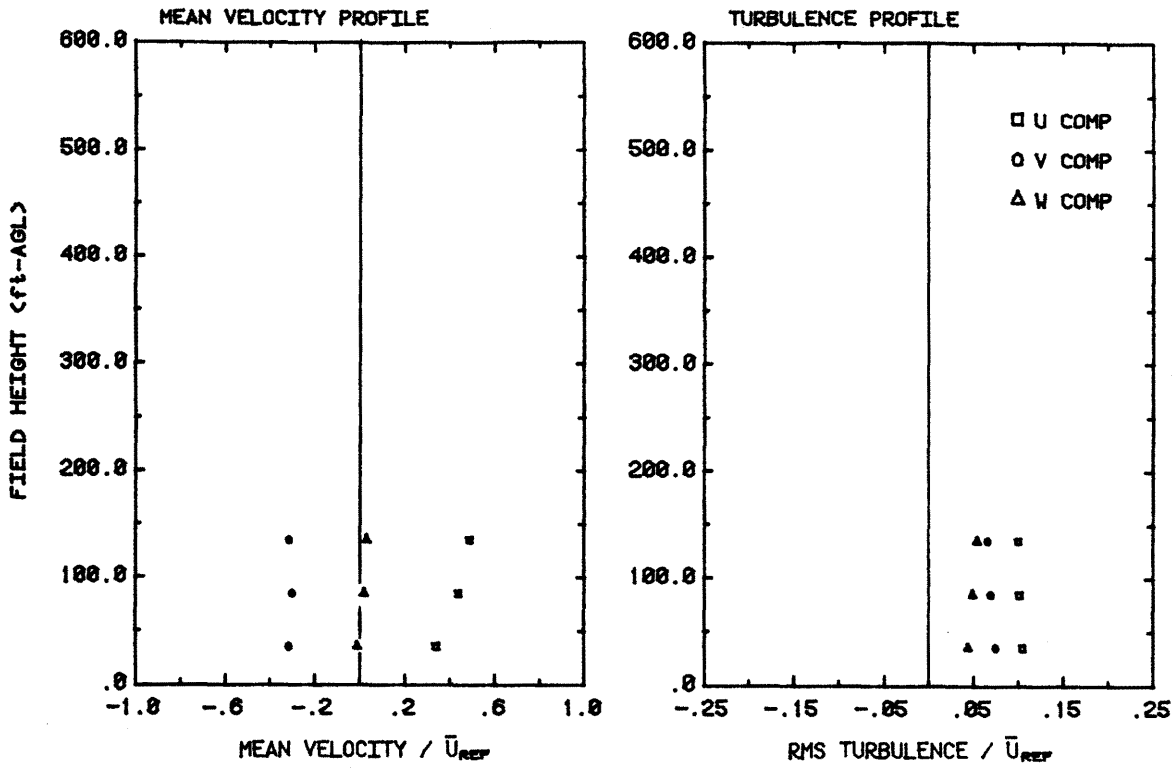


Figure E-111. Normalized mean velocities and turbulence intensity at location K5 for the west southwest (WSW) wind direction.

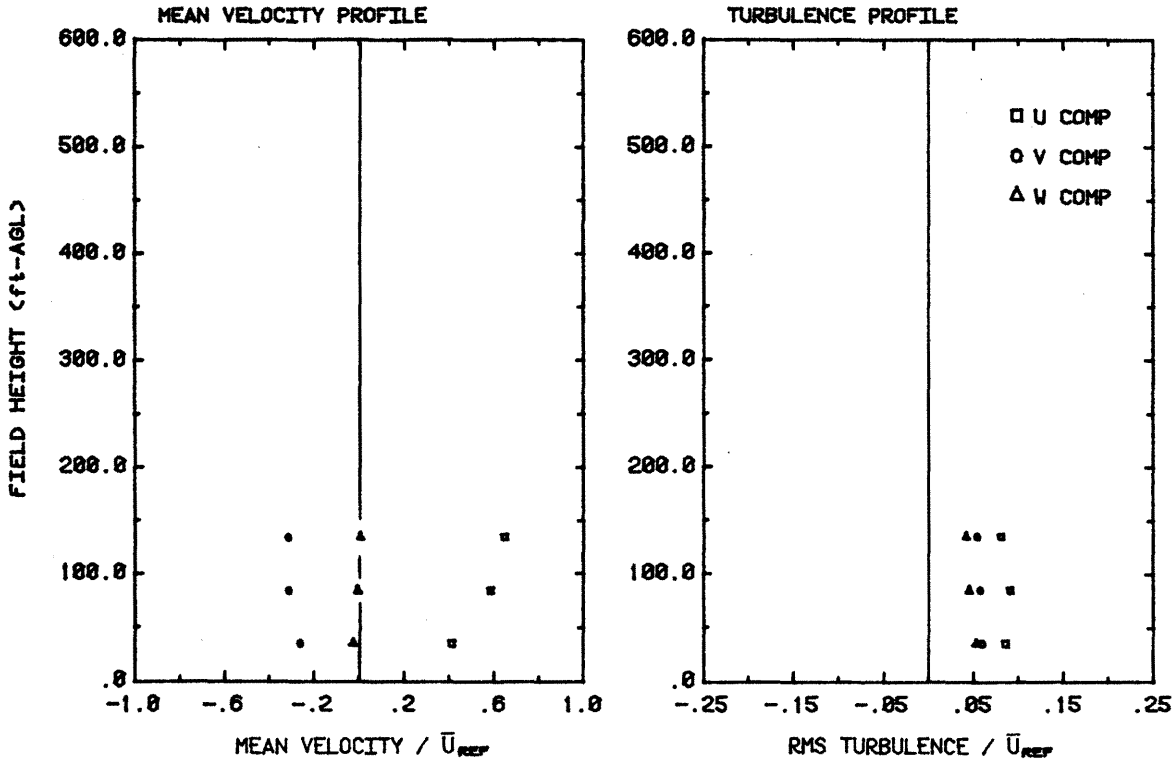


Figure E-112. Normalized mean velocities and turbulence intensity at location L5 for the west southwest (WSW) wind direction.

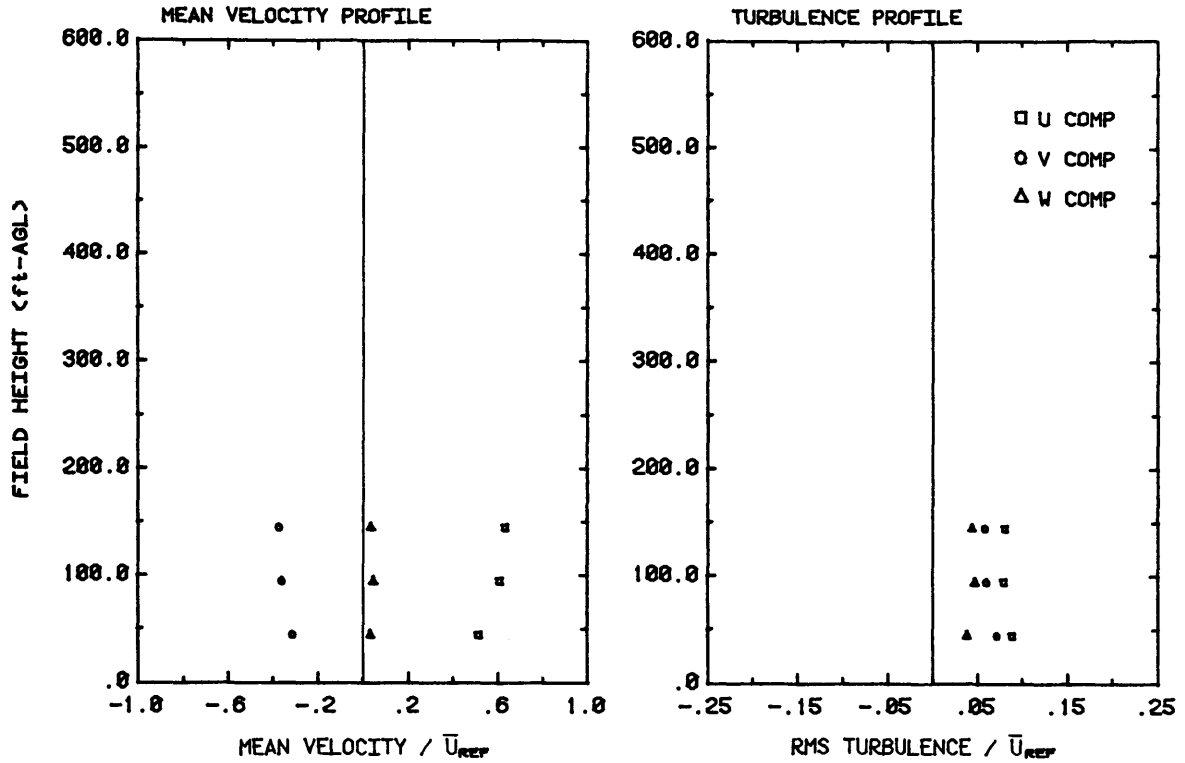


Figure E-113. Normalized mean velocities and turbulence intensity at location M5 for the west southwest (WSW) wind direction.

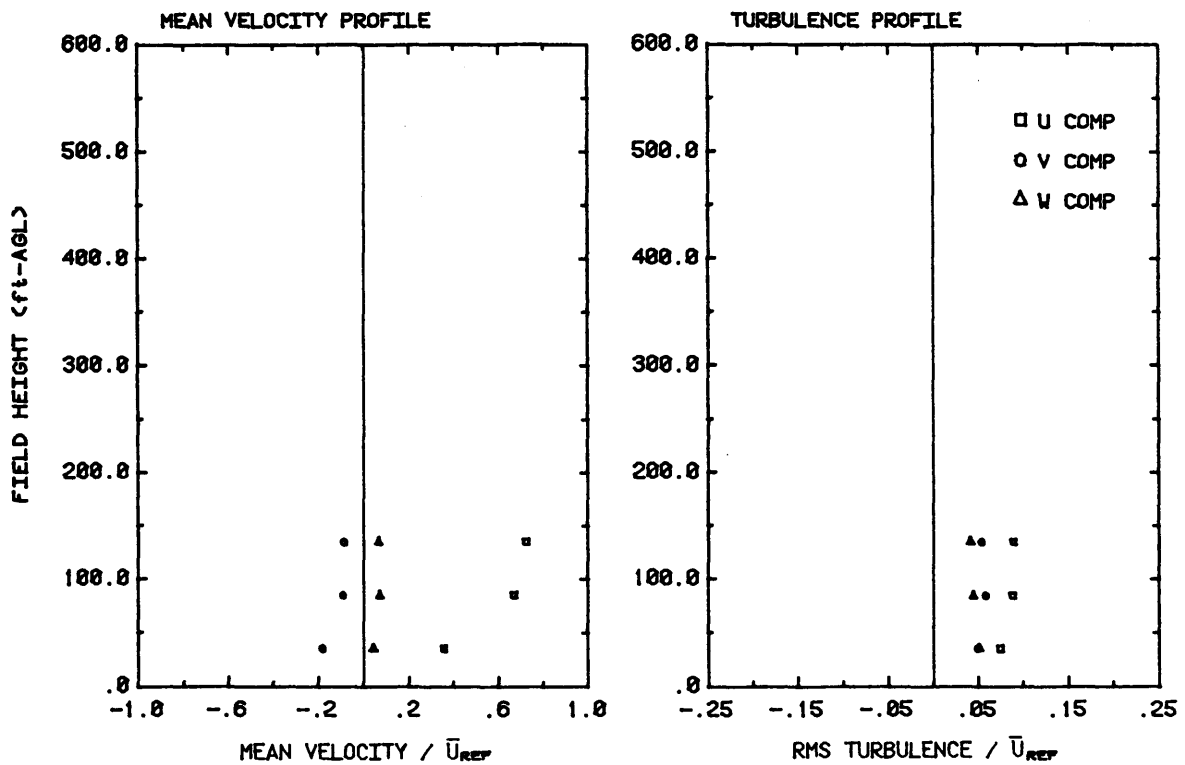


Figure E-114. Normalized mean velocities and turbulence intensity at location N1 for the west southwest (WSW) wind direction.

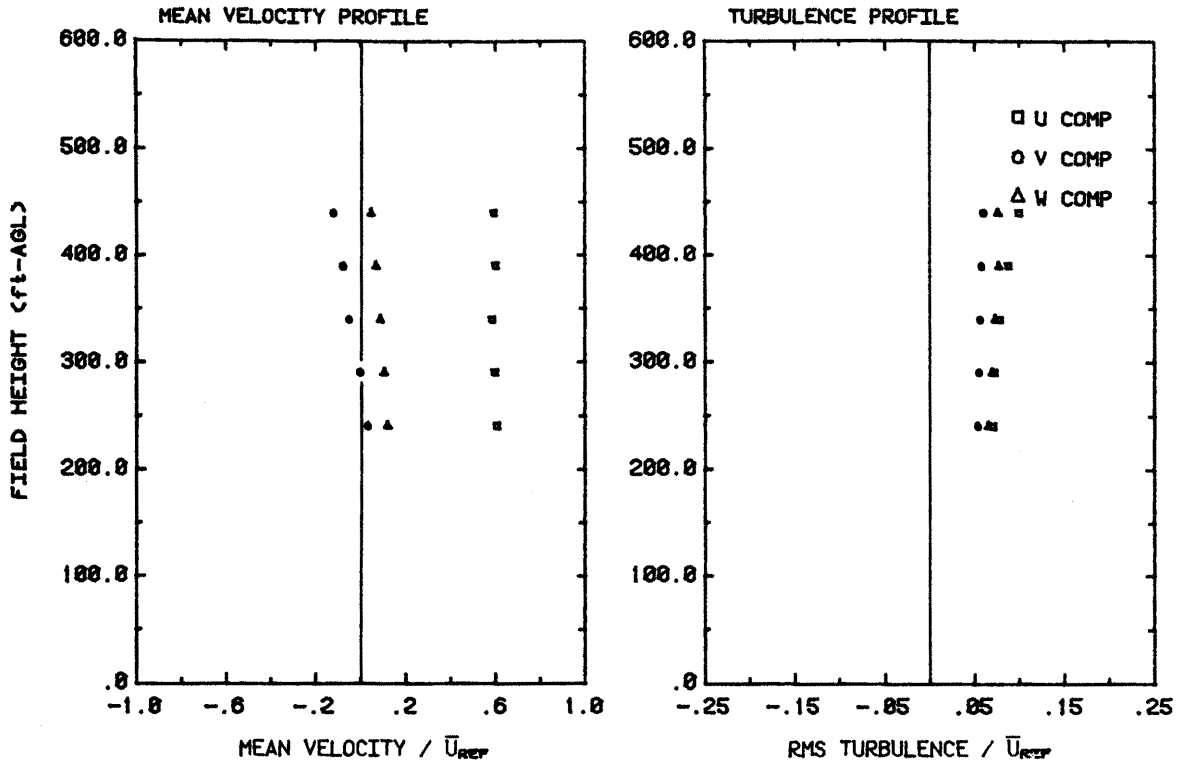


Figure E-115. Normalized mean velocities and turbulence intensity at location N2 for the west southwest (WSW) wind direction.

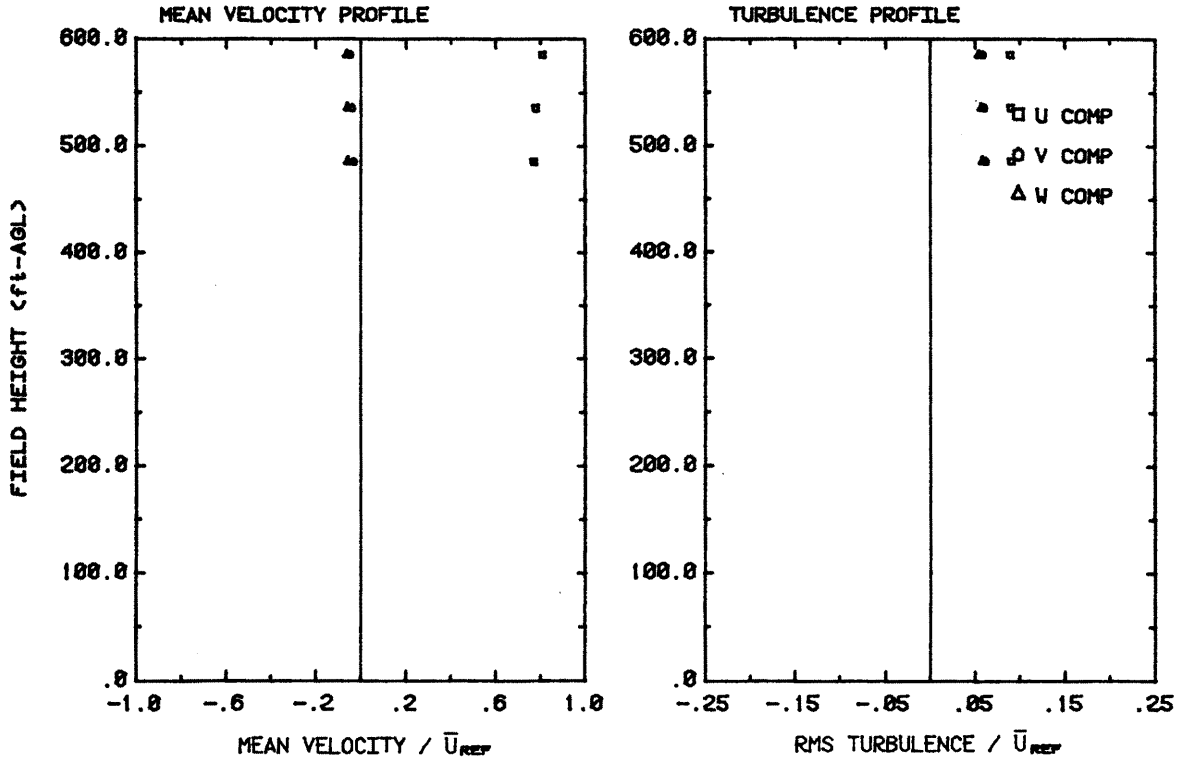


Figure E-116. Normalized mean velocities and turbulence intensity at location N3 for the west southwest (WSW) wind direction.

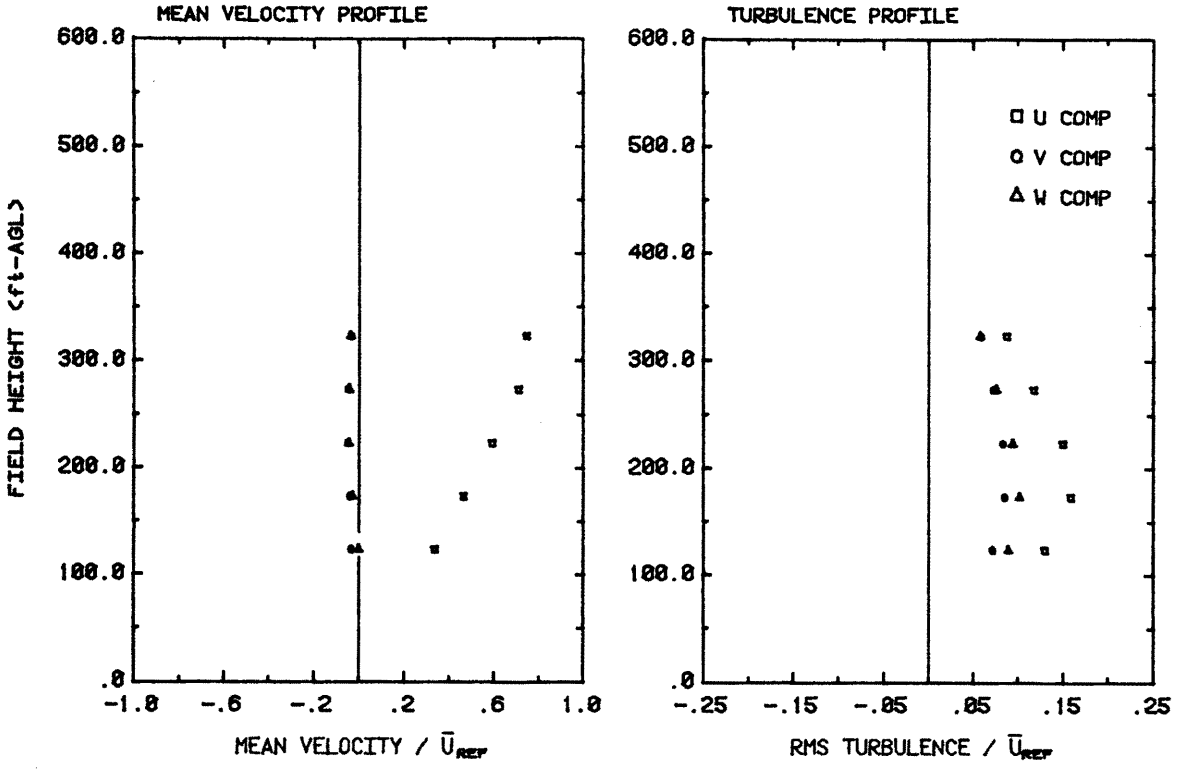


Figure E-117. Normalized mean velocities and turbulence intensity at location N4 for the west southwest (WSW) wind direction.

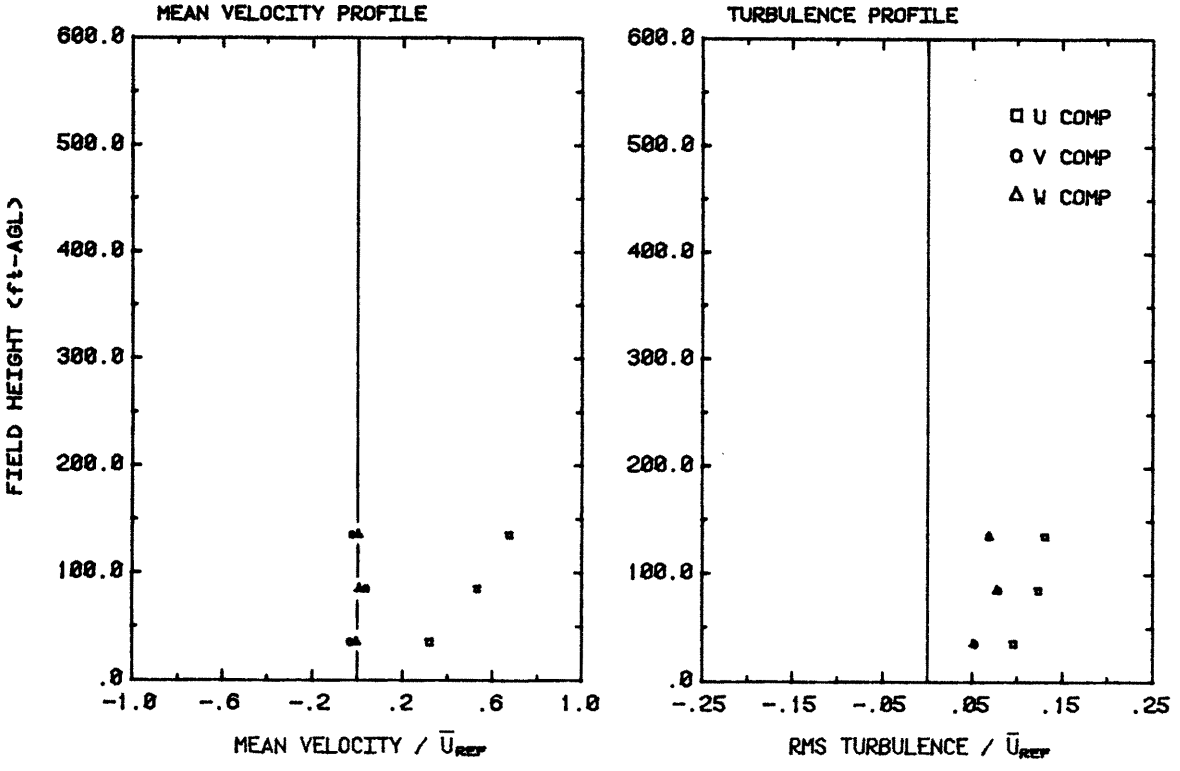


Figure E-118. Normalized mean velocities and turbulence intensity at location N5 for the west southwest (WSW) wind direction.

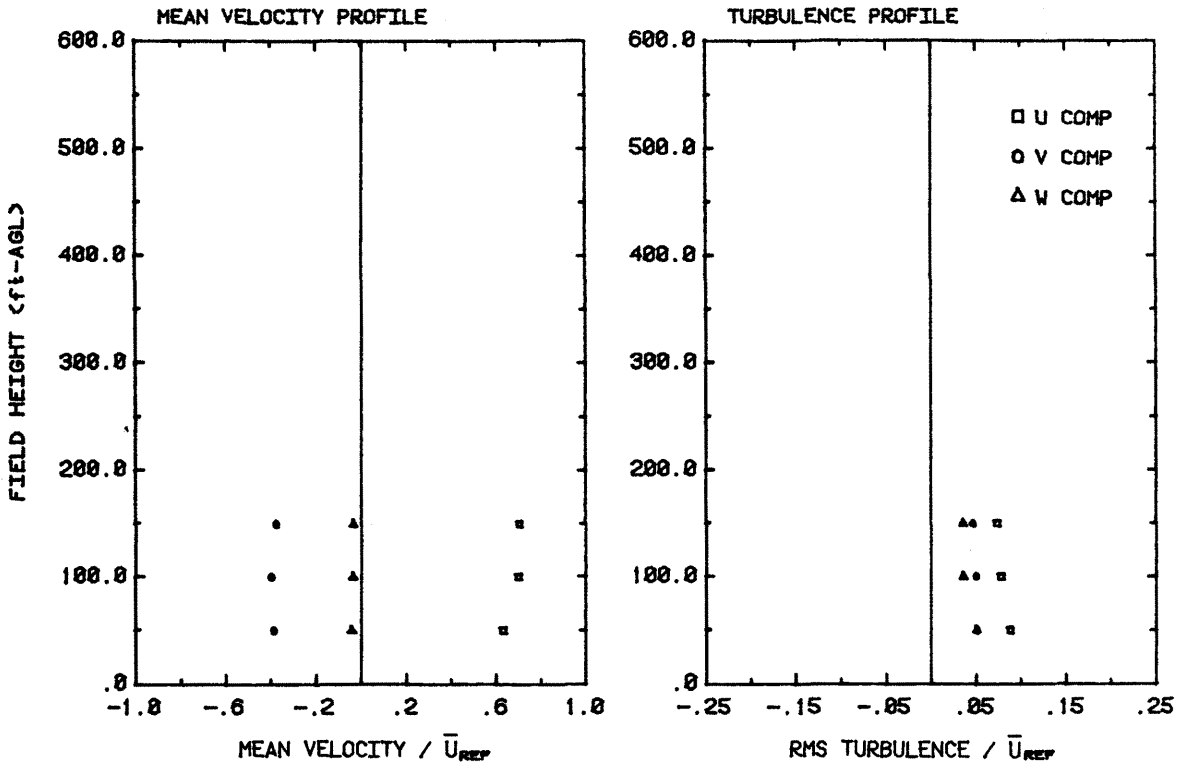


Figure E-119. Normalized mean velocities and turbulence intensity at location 01 for the west southwest (WSW) wind direction.

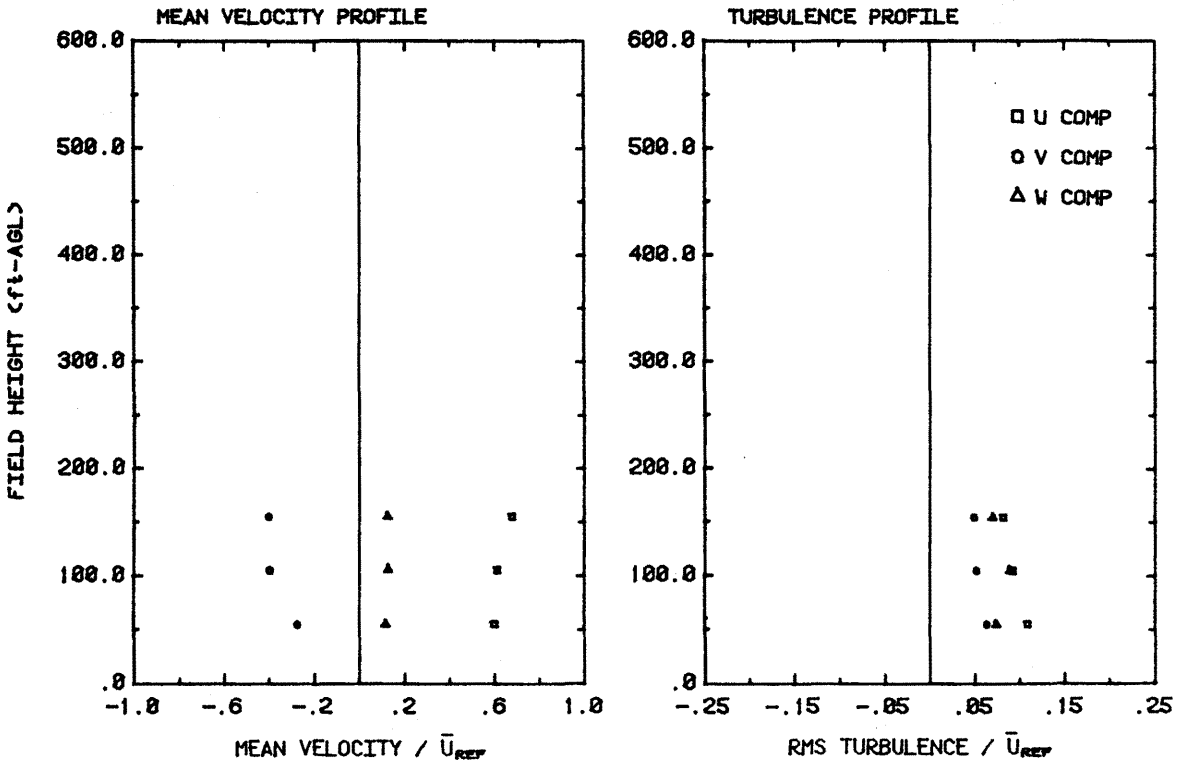


Figure E-120. Normalized mean velocities and turbulence intensity at location 05 for the west southwest (WSW) wind direction.

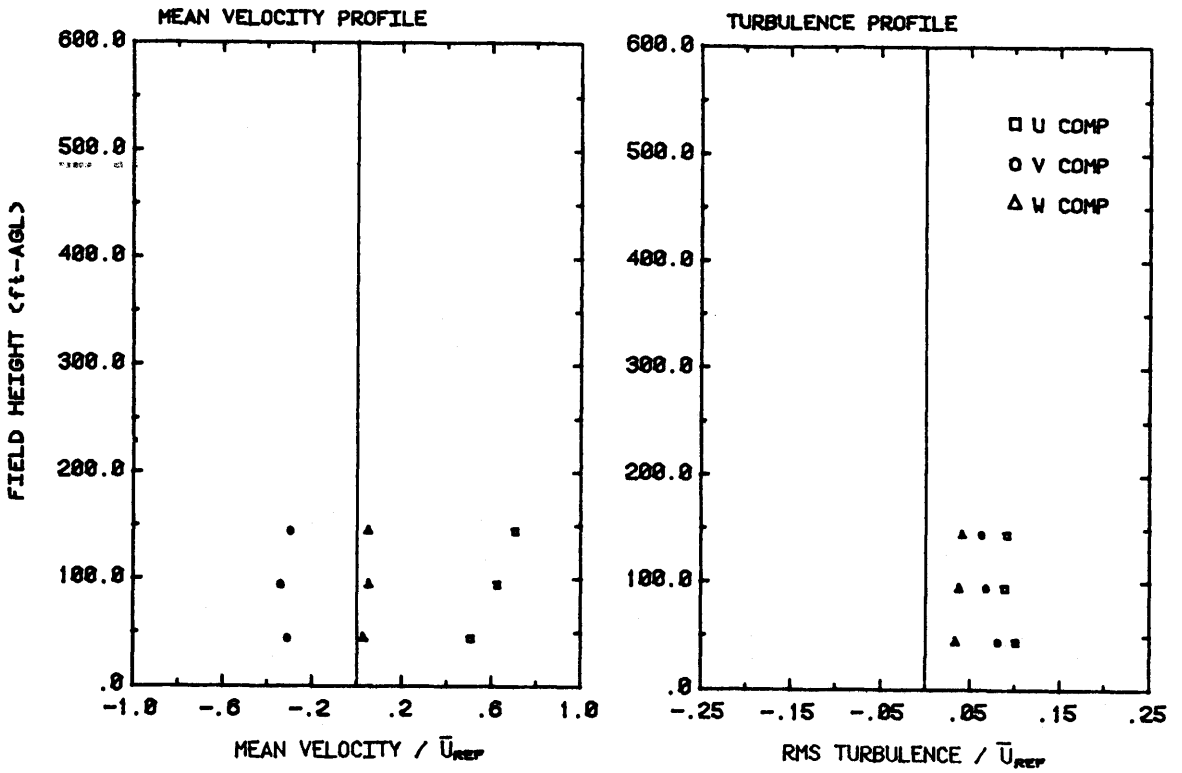


Figure E-121. Normalized mean velocities and turbulence intensity at location P1 for the west southwest (WSW) wind direction.

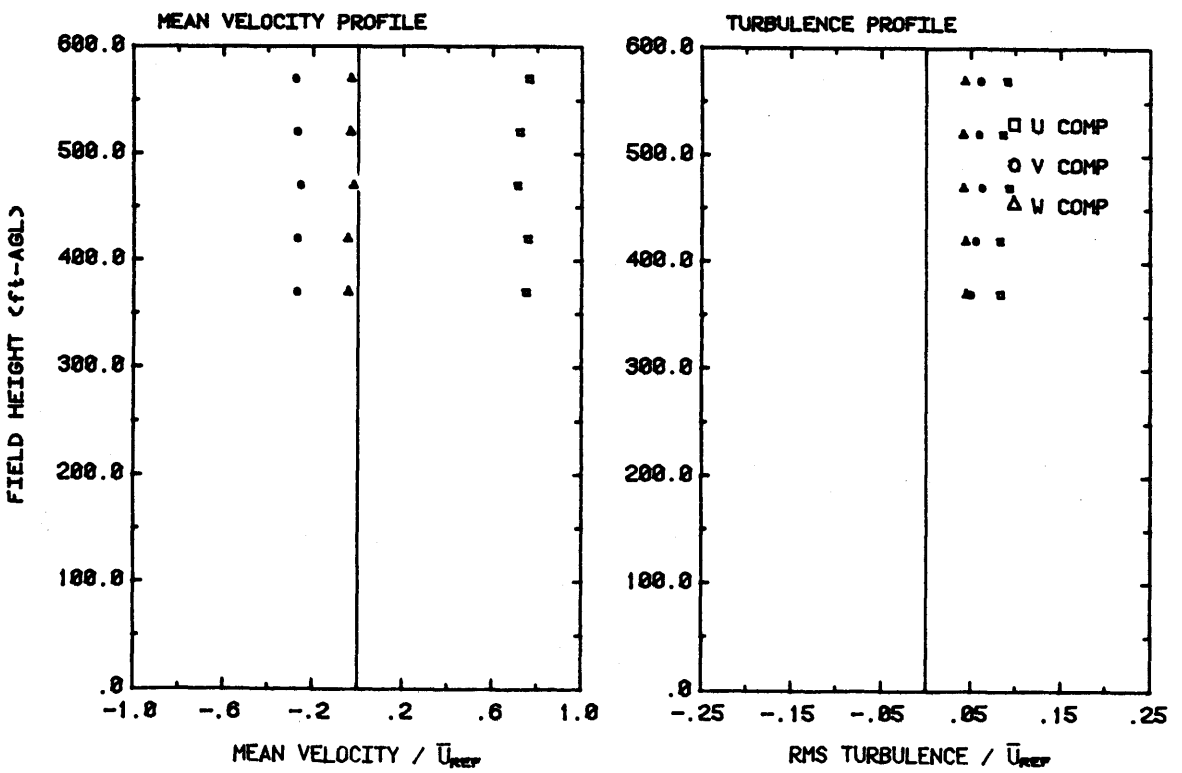


Figure E-122. Normalized mean velocities and turbulence intensity at location P2 for the west southwest (WSW) wind direction.

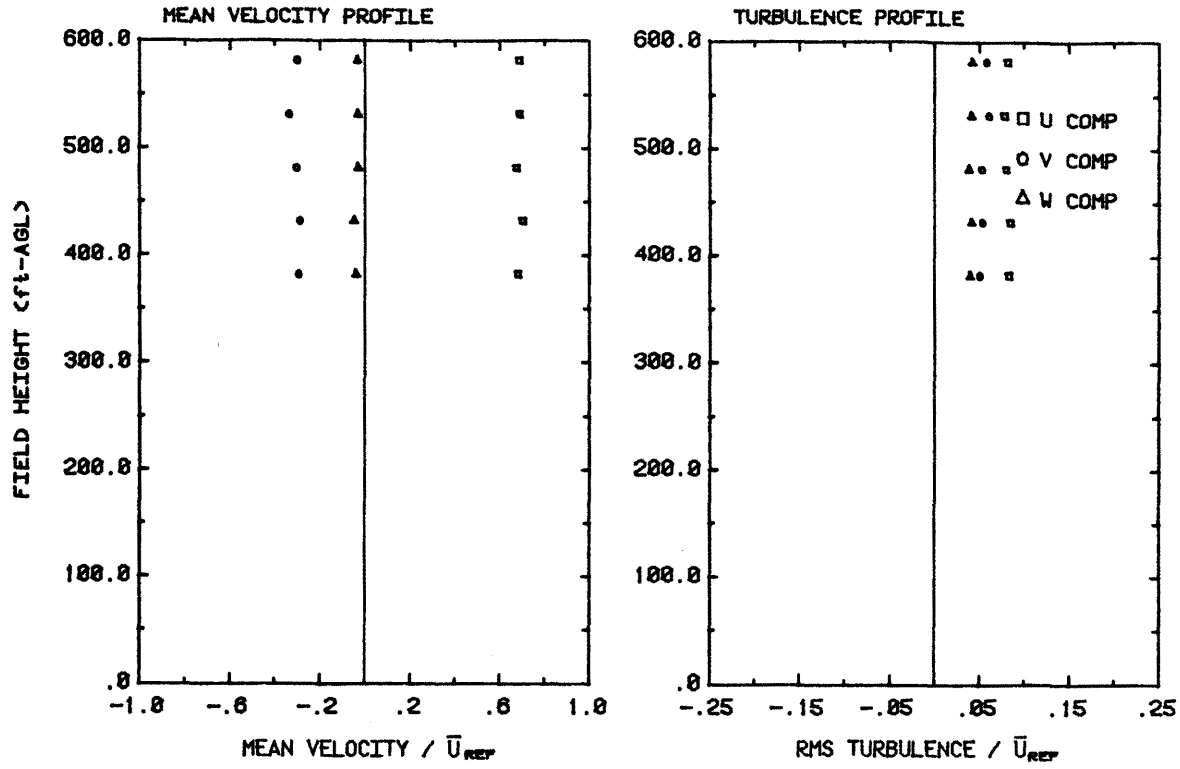


Figure E-123. Normalized mean velocities and turbulence intensity at location P3 for the west southwest (WSW) wind direction.

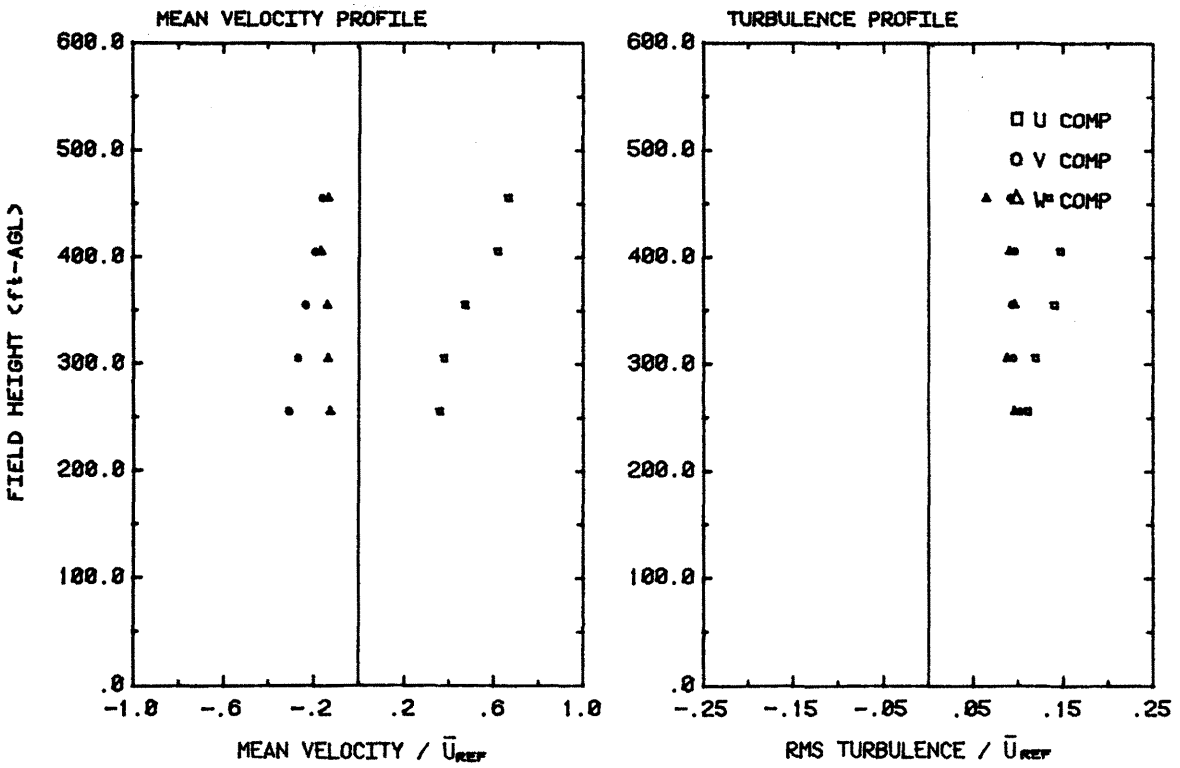


Figure E-124. Normalized mean velocities and turbulence intensity at location P4 for the west southwest (WSW) wind direction.

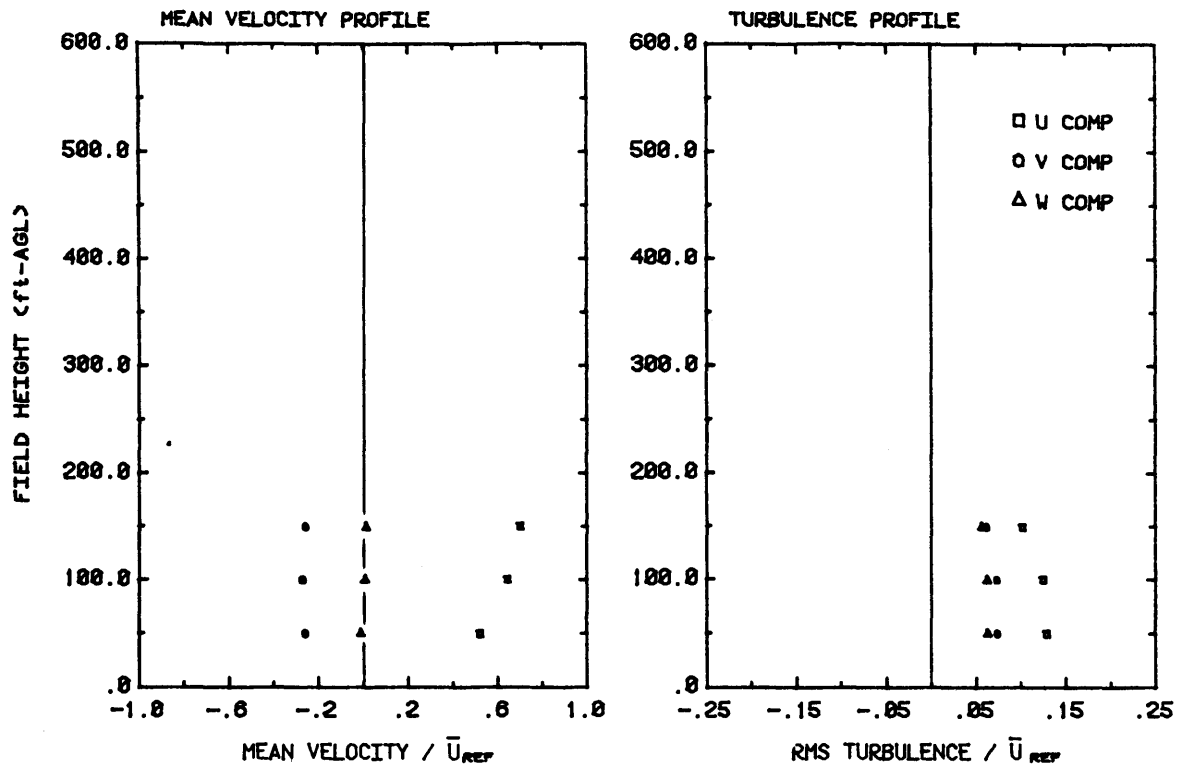


Figure E-125. Normalized mean velocities and turbulence intensity at location P5 for the west southwest (WSW) wind direction.

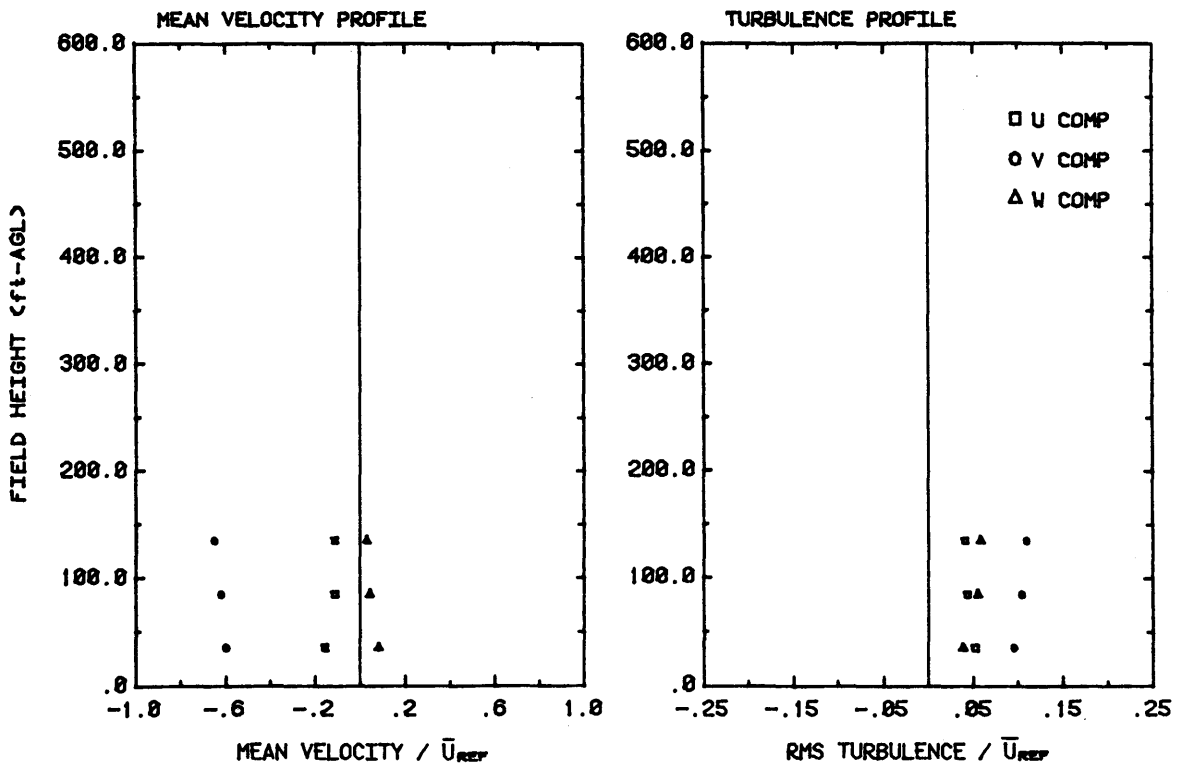


Figure E-126. Normalized mean velocities and turbulence intensity at location Q1 for the west southwest (WSW) wind direction.

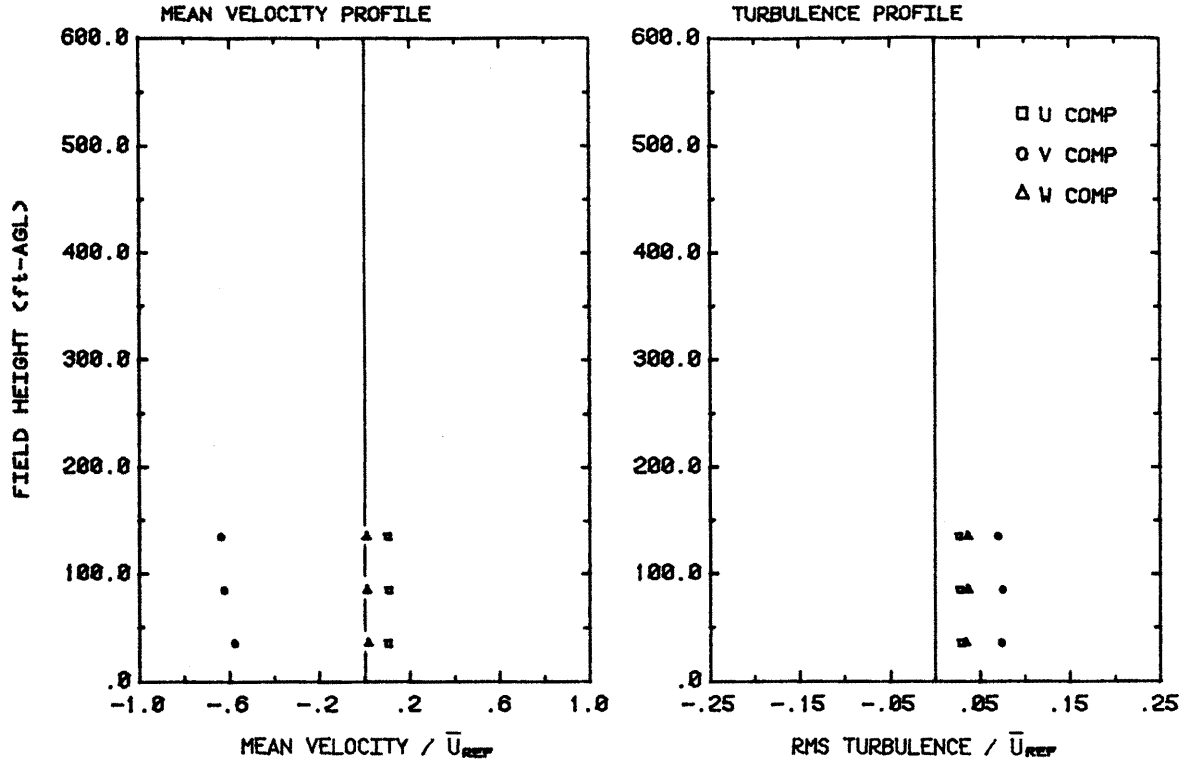


Figure E-127. Normalized mean velocities and turbulence intensity at location Q5 for the west southwest (WSW) wind direction.

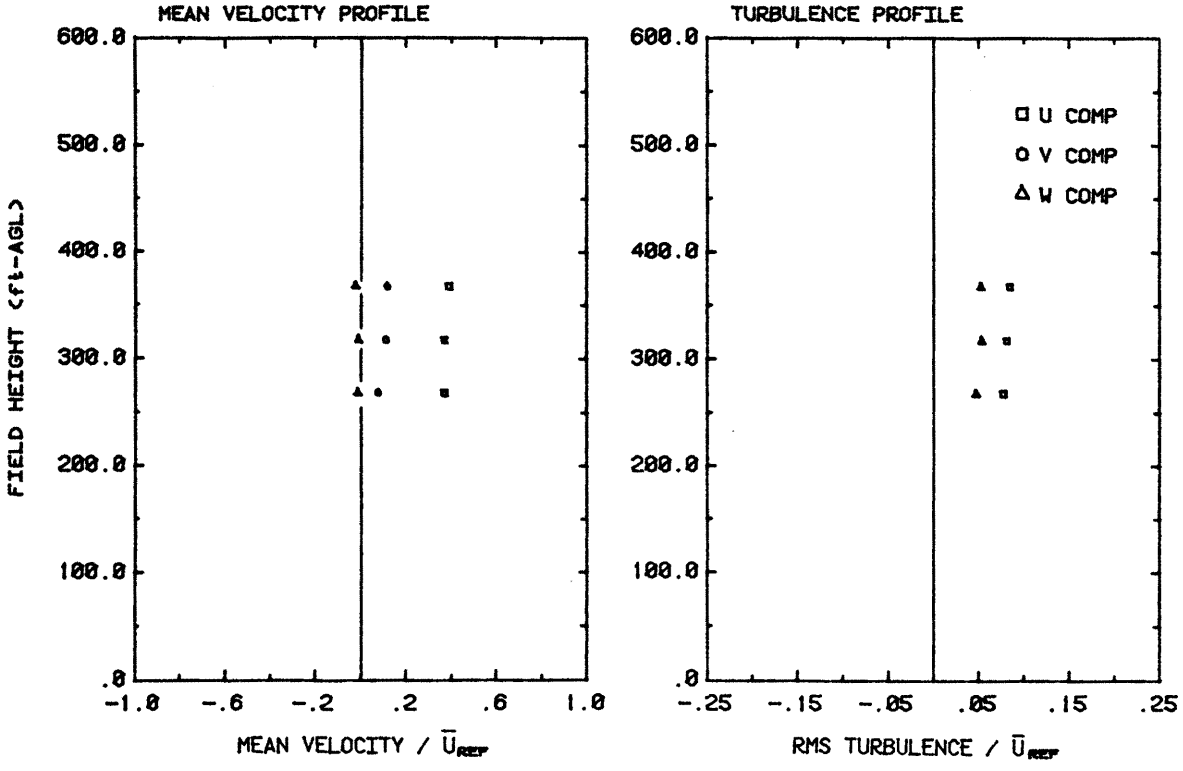


Figure E-128. Normalized mean velocities and turbulence intensity at location A3 for the north northeast (NNE) wind direction.

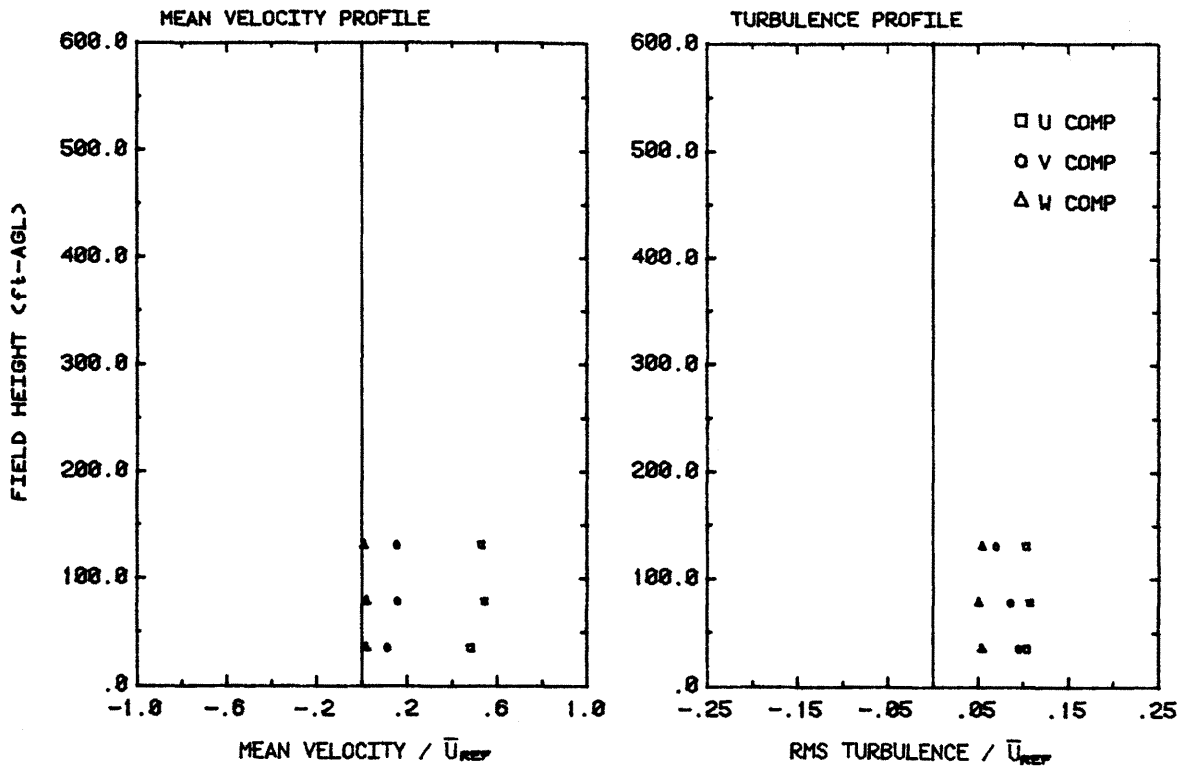


Figure E-129. Normalized mean velocities and turbulence intensity at location A5 for the north northeast (NNE) wind direction.

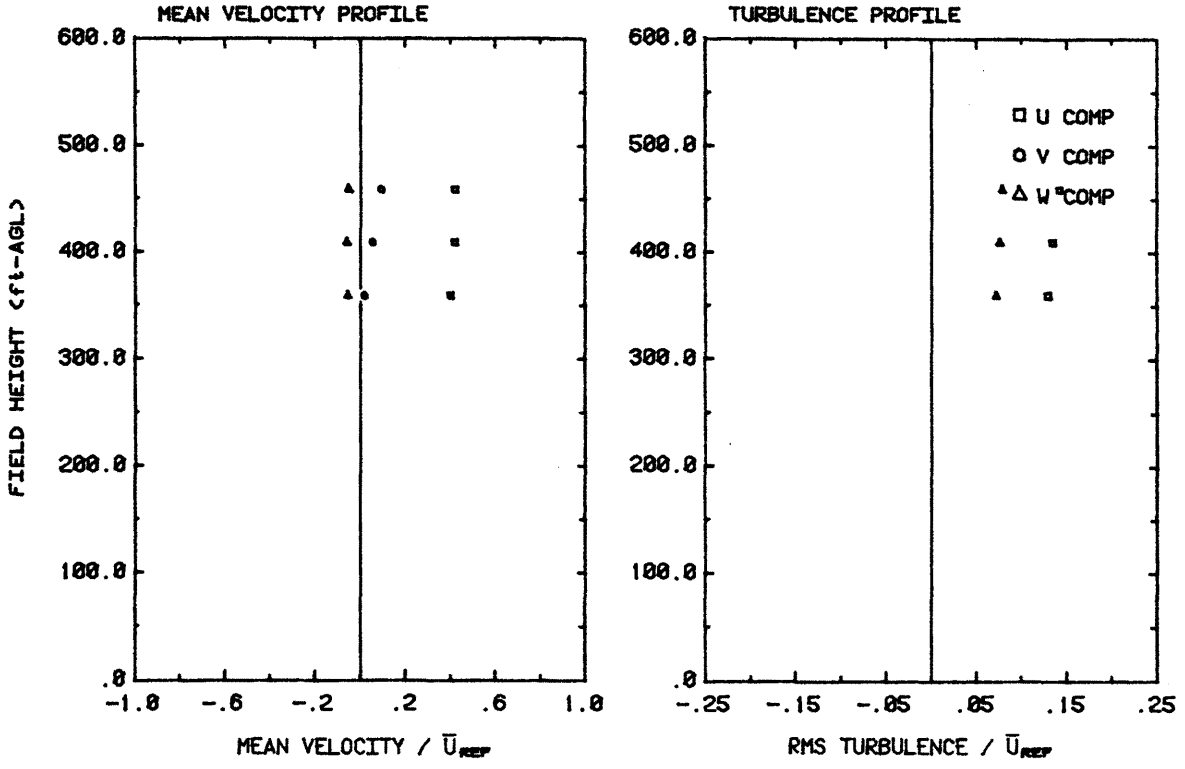


Figure E-130. Normalized mean velocities and turbulence intensity at location K3 for the north northeast (NNE) wind direction.

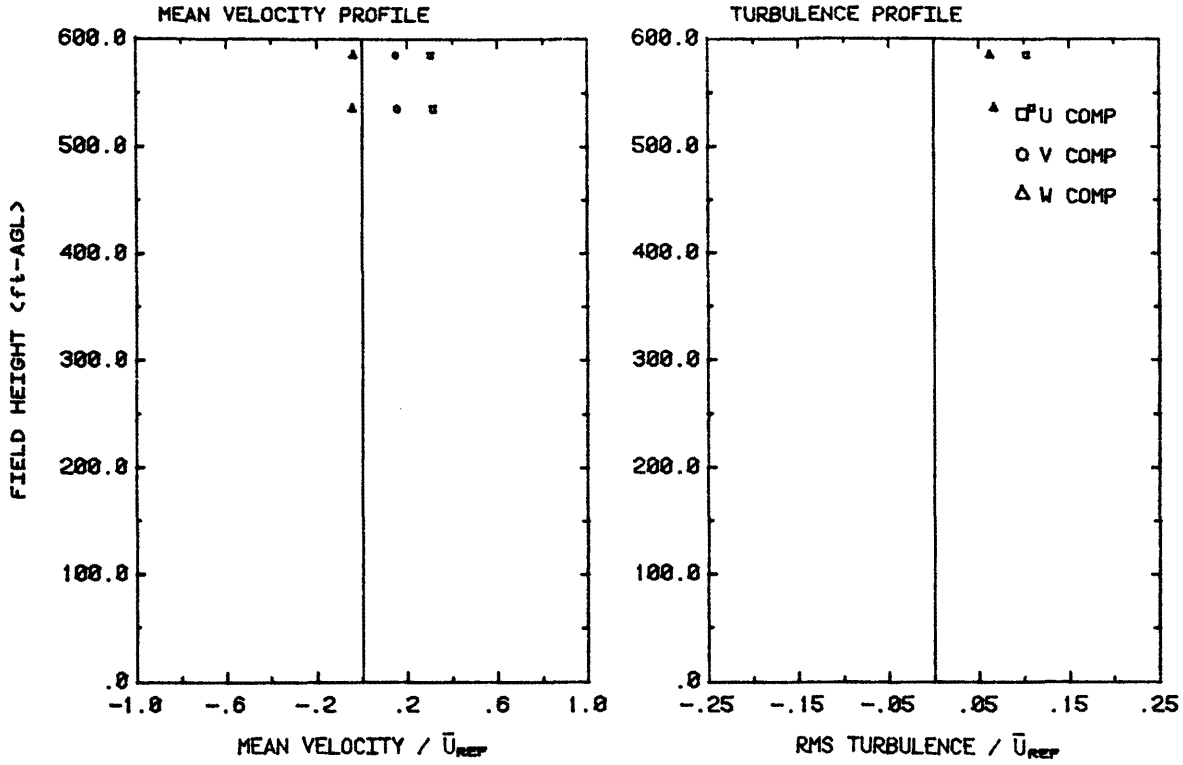


Figure E-131. Normalized mean velocities and turbulence intensity at location N3 for the north northeast (NNE) wind direction.

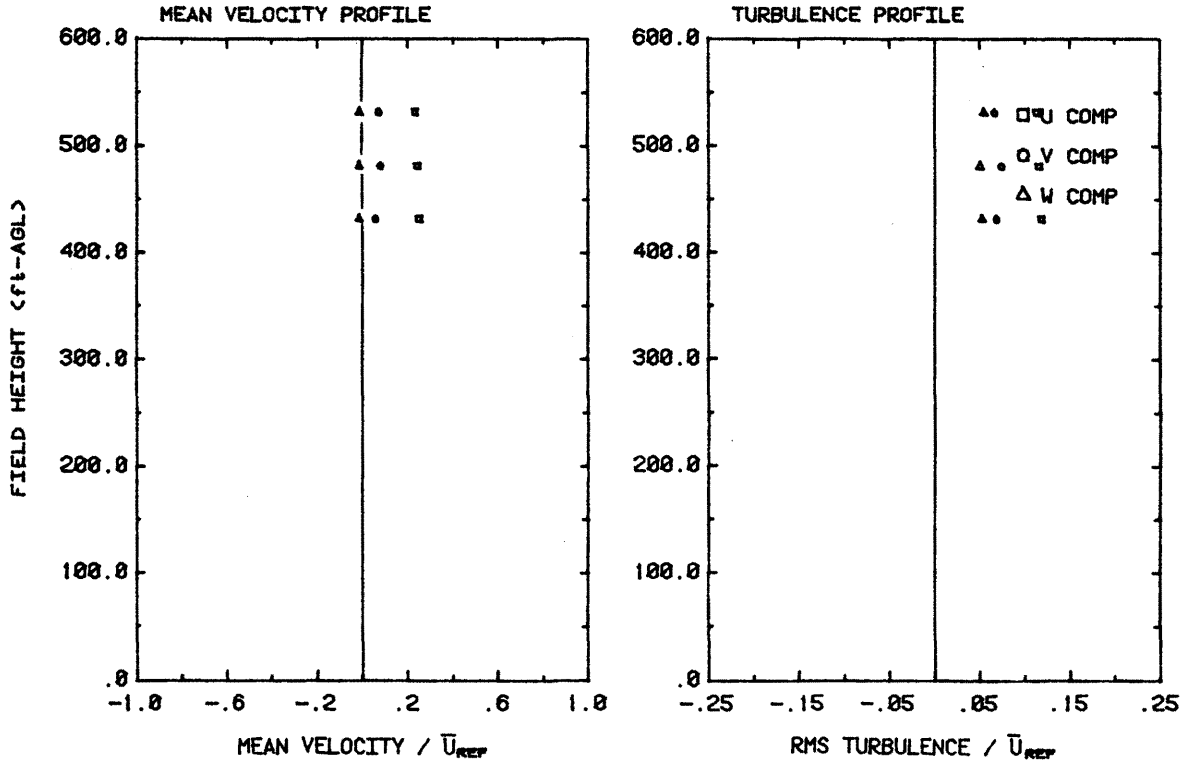


Figure E-132. Normalized mean velocities and turbulence intensity at location P3 for the north northeast (NNE) wind direction.

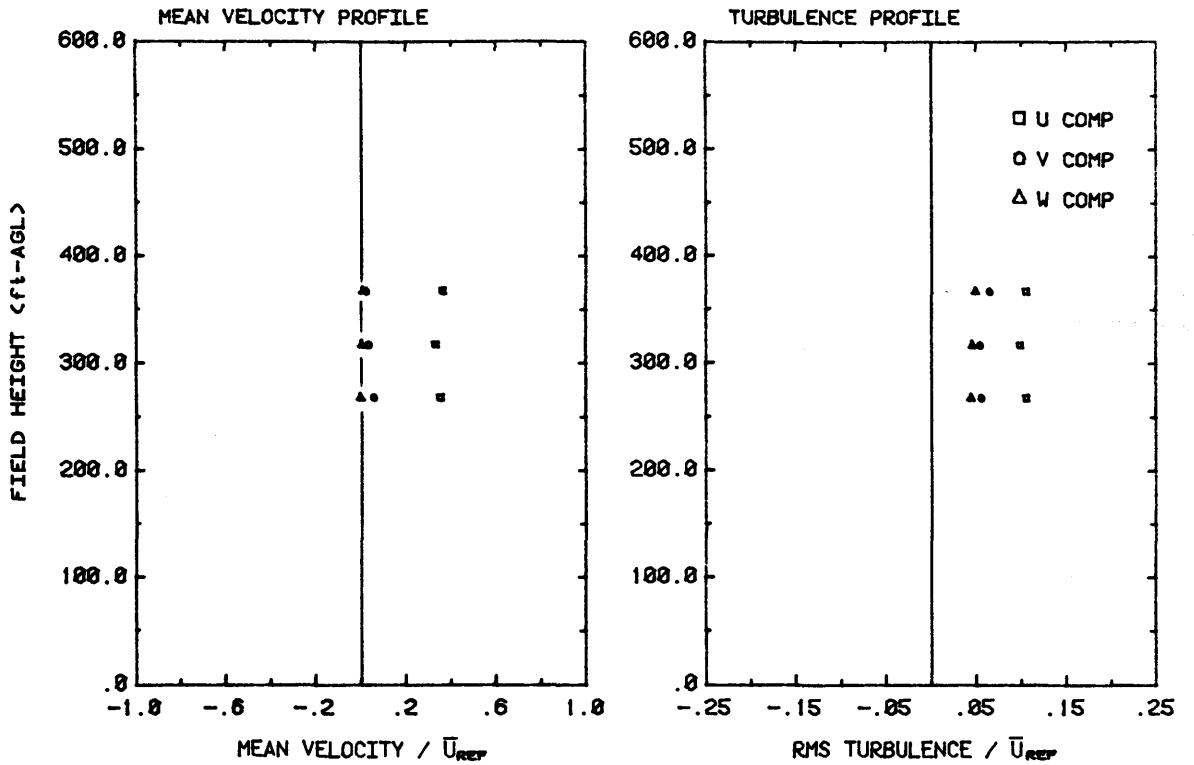


Figure E-133. Normalized mean velocities and turbulence intensity at location A3 for the east northeast (ENE) wind direction.

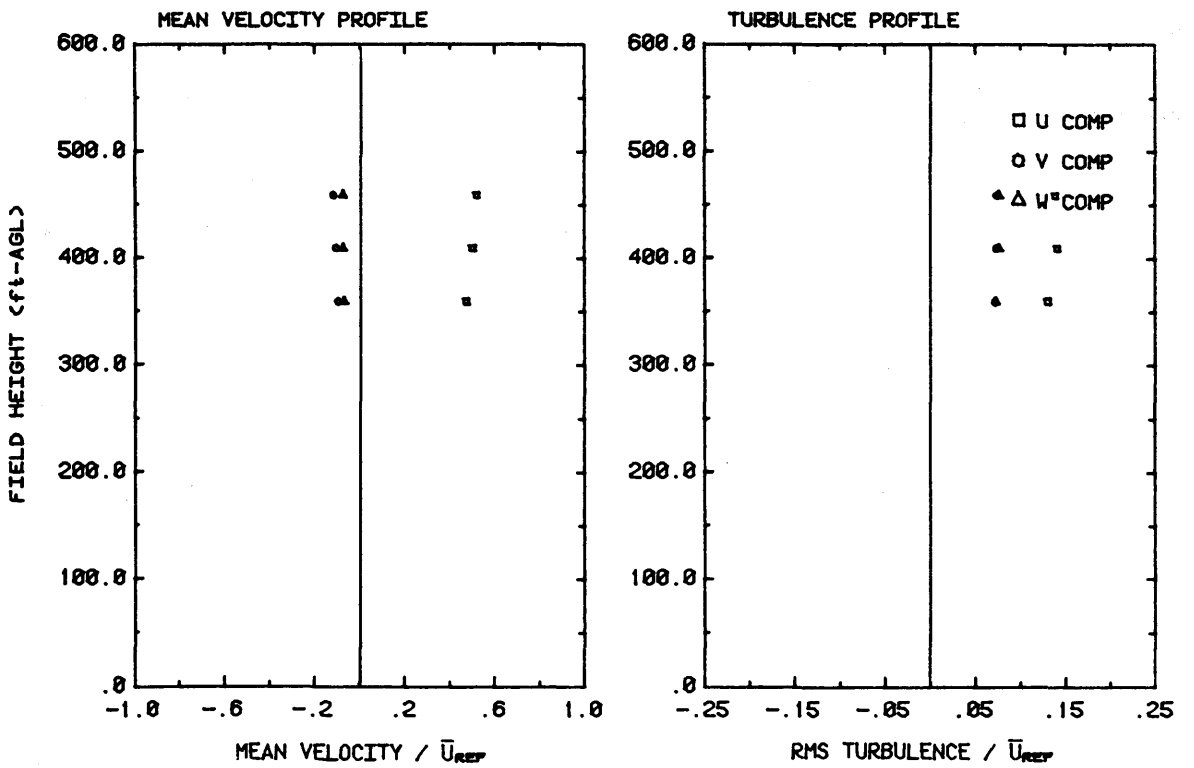


Figure E-134. Normalized mean velocities and turbulence intensity at location K3 for the east northeast (ENE) wind direction.

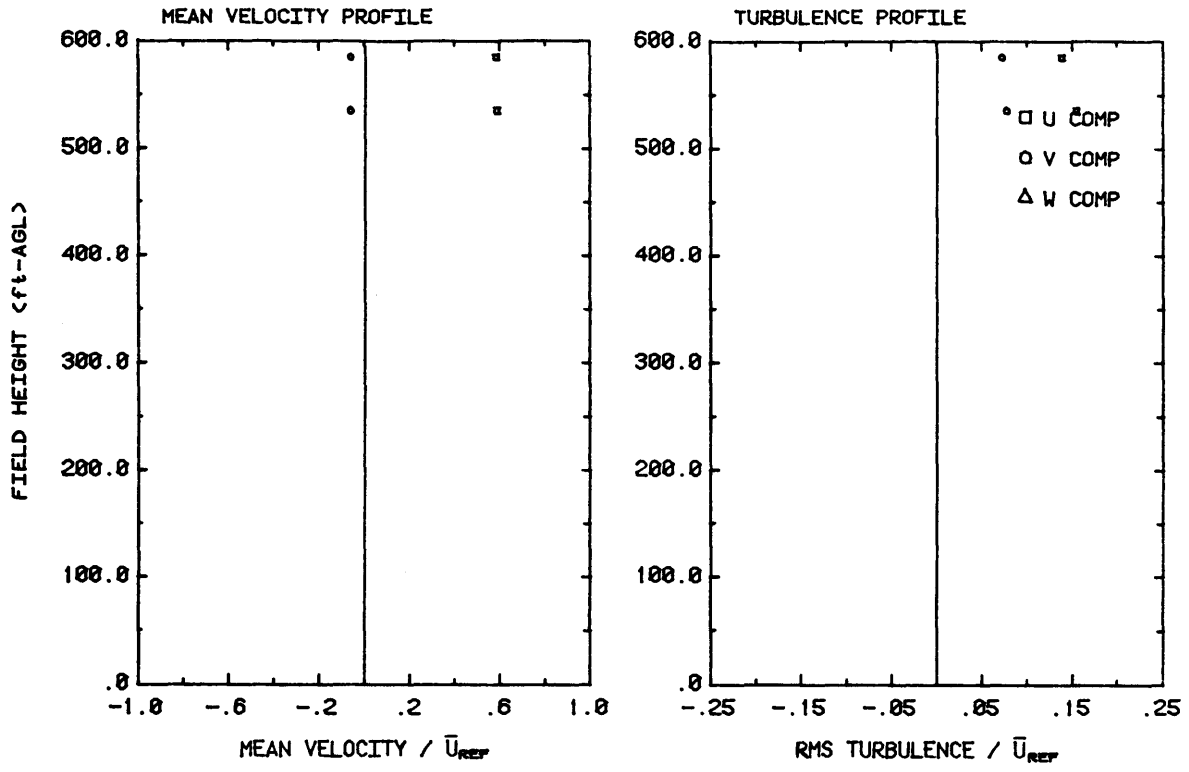


Figure E-135. Normalized mean velocities and turbulence intensity at location N3 for the east northeast (ENE) wind direction.

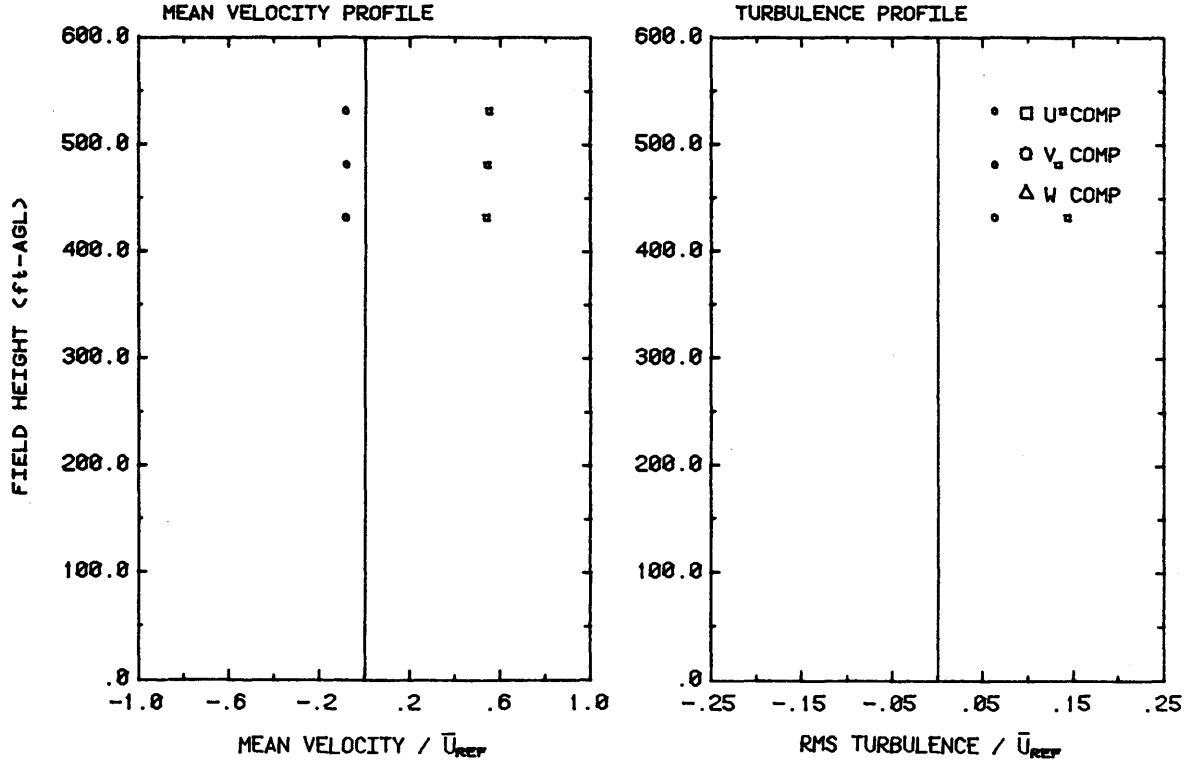


Figure E-136. Normalized mean velocities and turbulence intensity at location P3 for the east northeast (ENE) wind direction.

APPENDIX F

CROSS-SPAN VELOCITIES

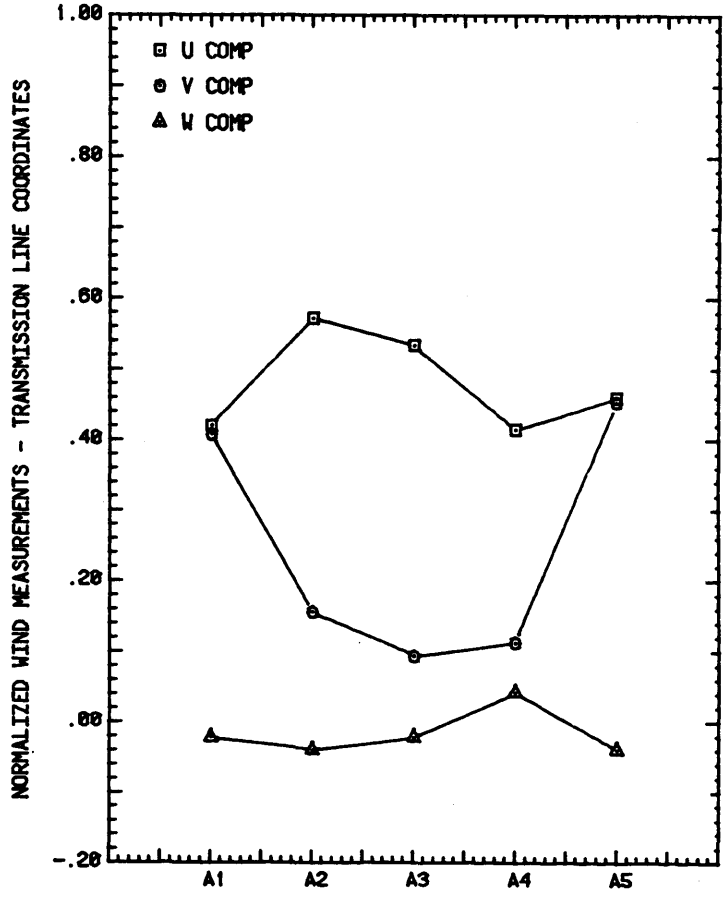


Figure F-1. Transmission line height mean speeds for Span A for the south (S) wind direction.

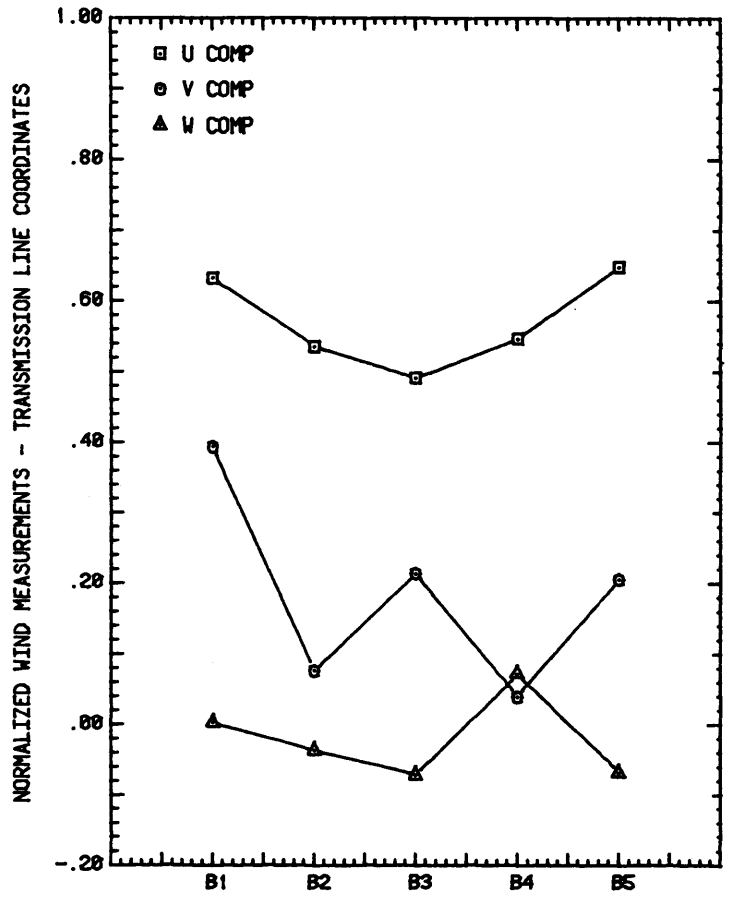


Figure F-2. Transmission line height mean speeds for Span B for the south (S) wind direction.

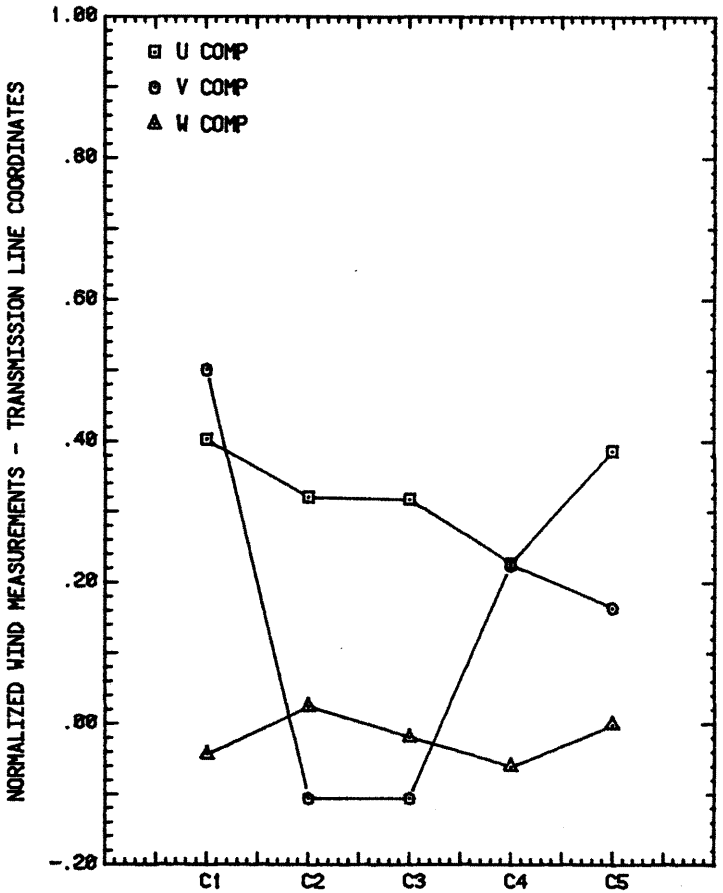


Figure F-3. Transmission line height mean speeds for Span C for the south (S) wind direction.

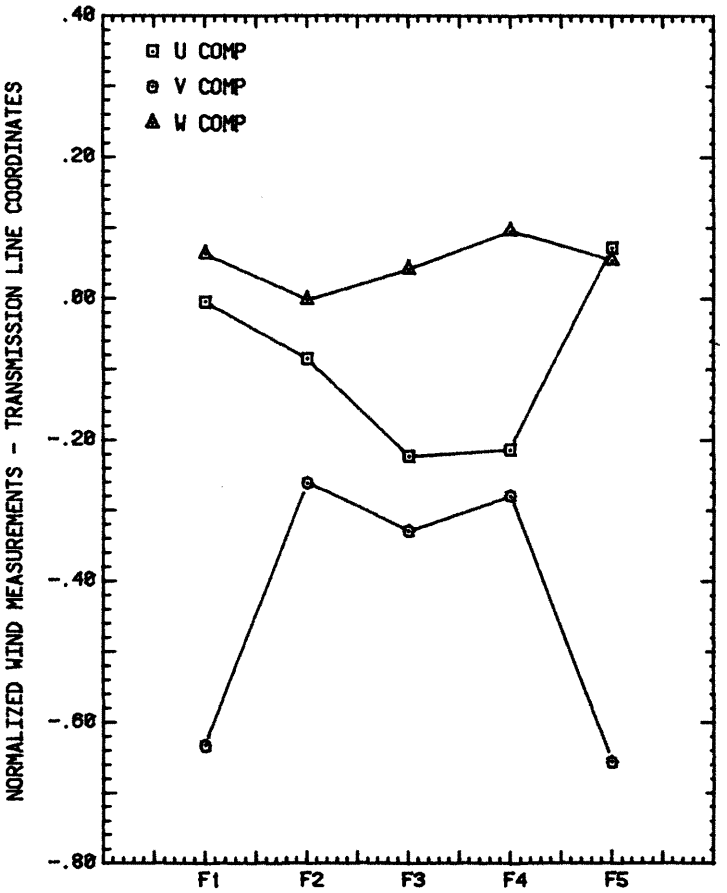


Figure F-4. Transmission line height mean speeds for Span F for the south (S) wind direction.

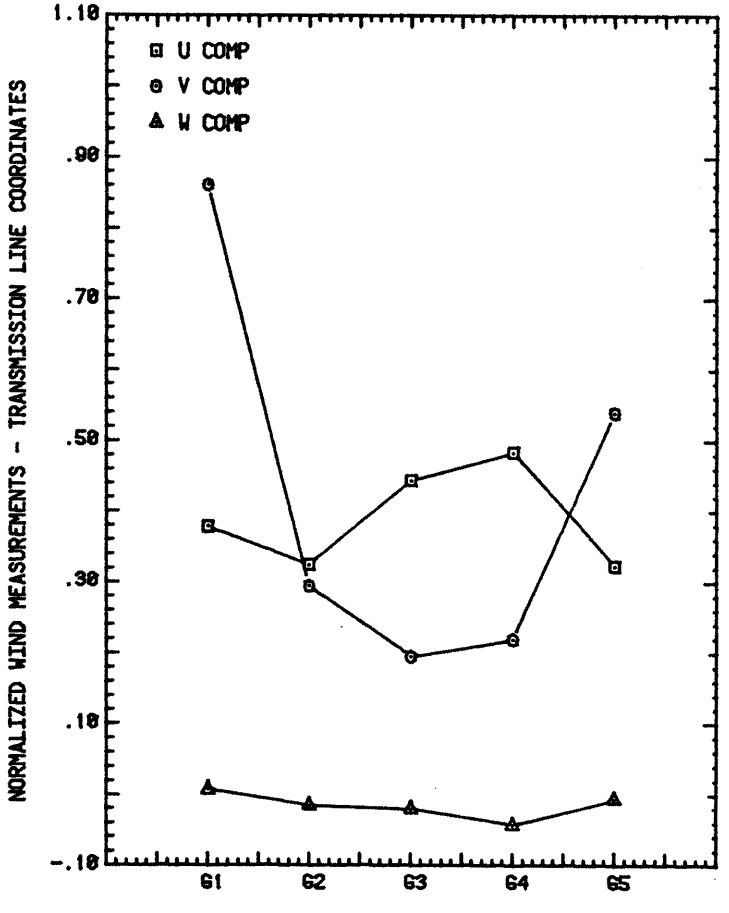


Figure F-5. Transmission line height mean speeds for Span G for the south (S) wind direction.

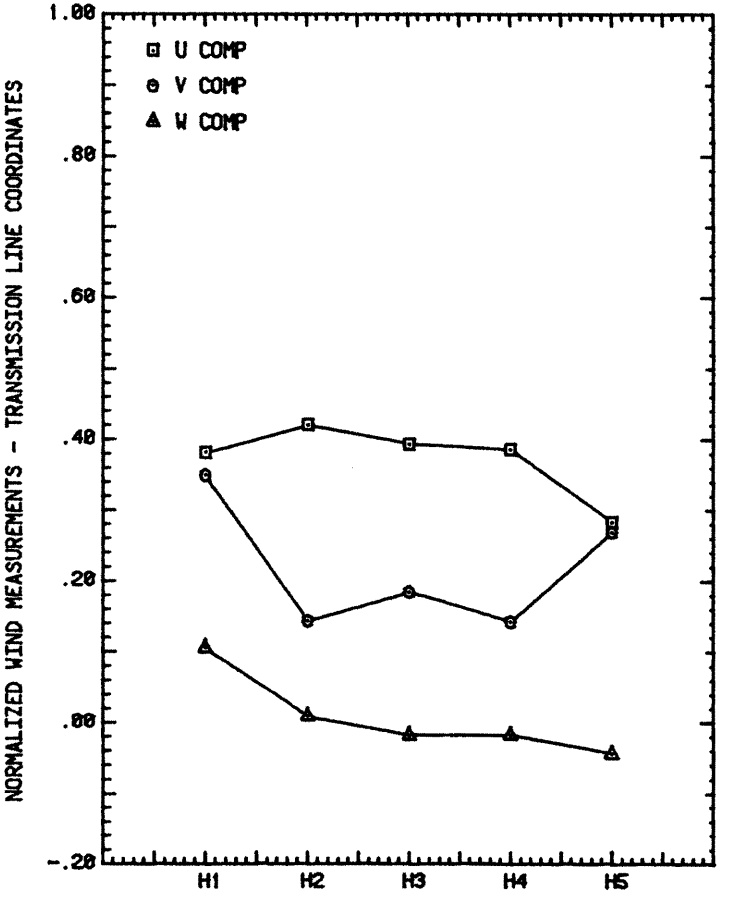


Figure F-6. Transmission line height mean speeds for Span H for the south (S) wind direction.

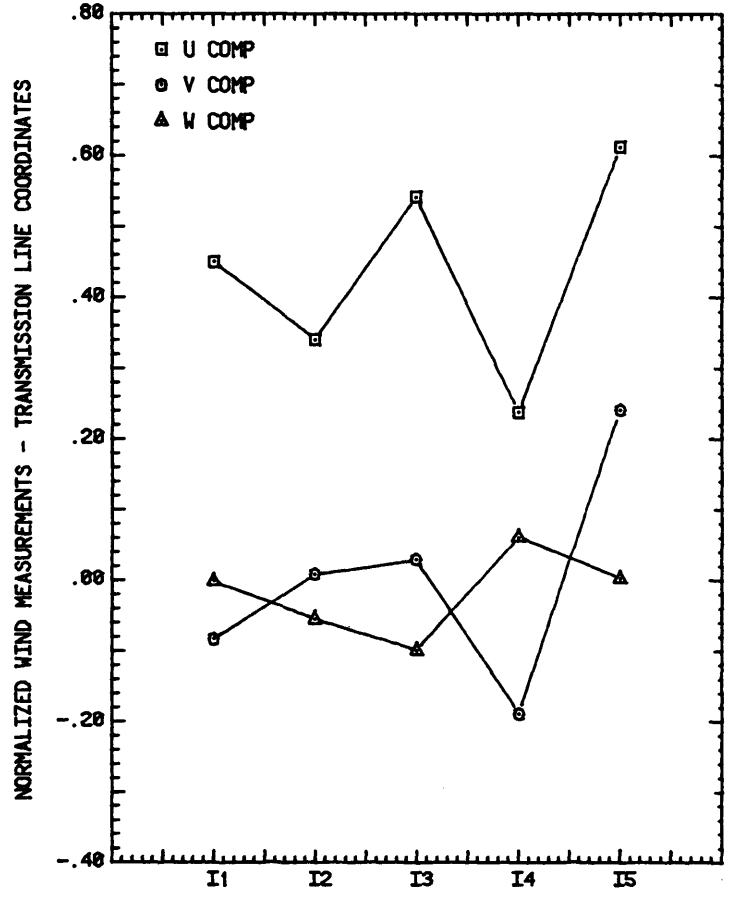


Figure F-7. Transmission line height mean speeds for Span I for the south (S) wind direction.

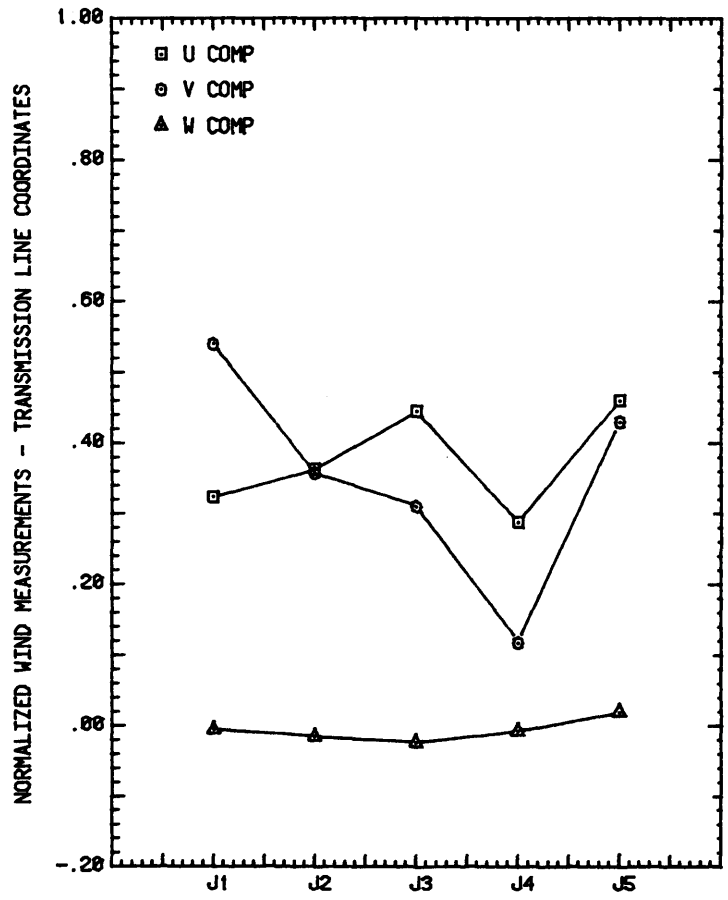


Figure F-8. Transmission line height mean speeds for Span J for the south (S) wind direction.

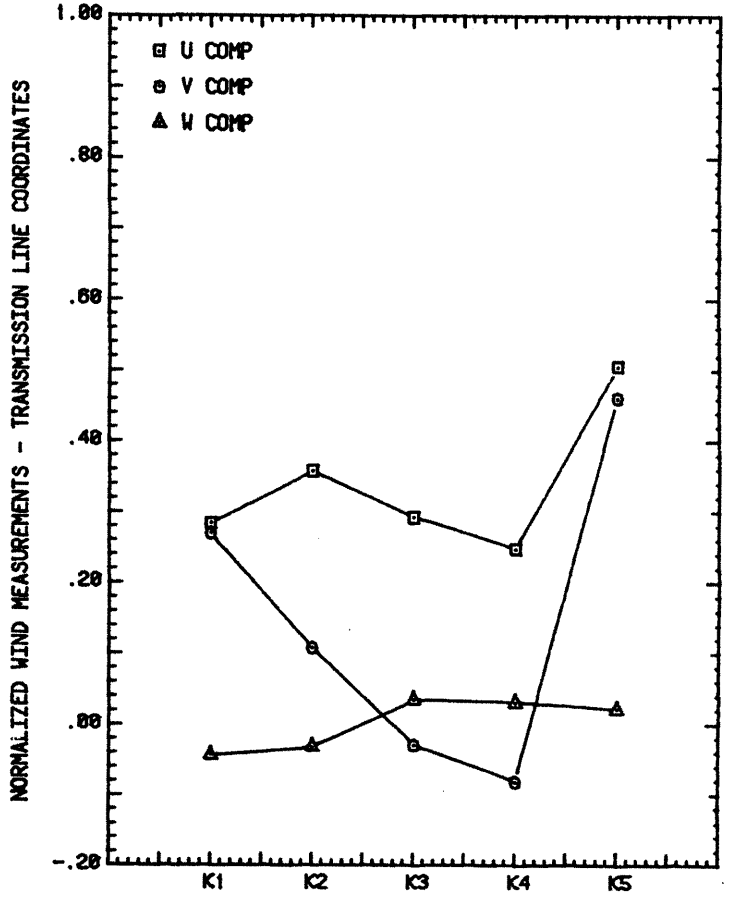


Figure F-9. Transmission line height mean speeds for Span K for the south (S) wind direction.

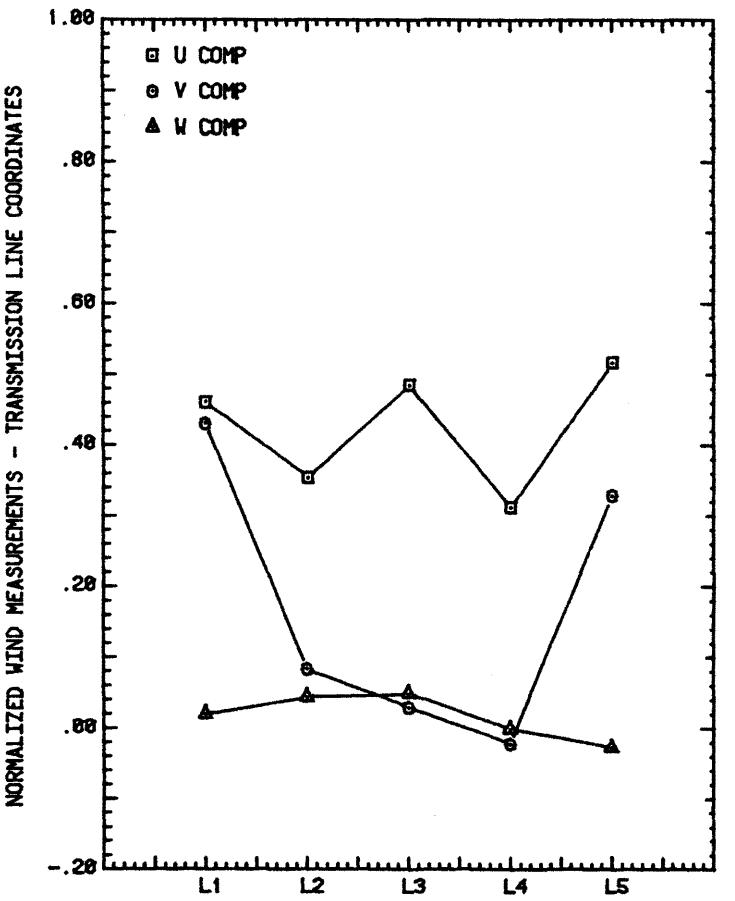


Figure F-10. Transmission line height mean speeds for Span L for the south (S) wind direction.

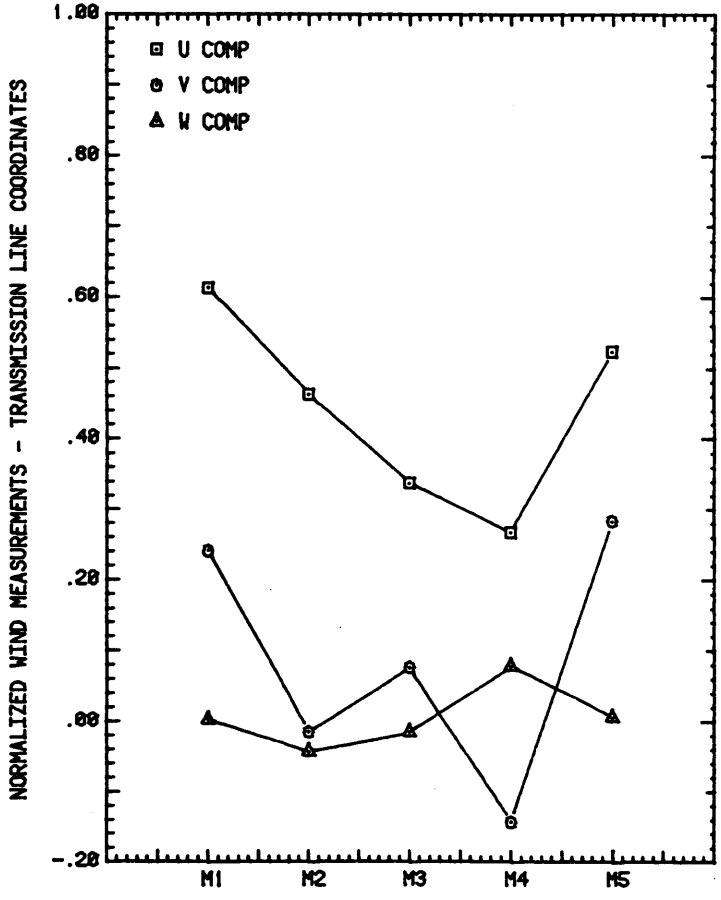


Figure F-11. Transmission line height mean speeds for Span M for the south (S) wind direction.

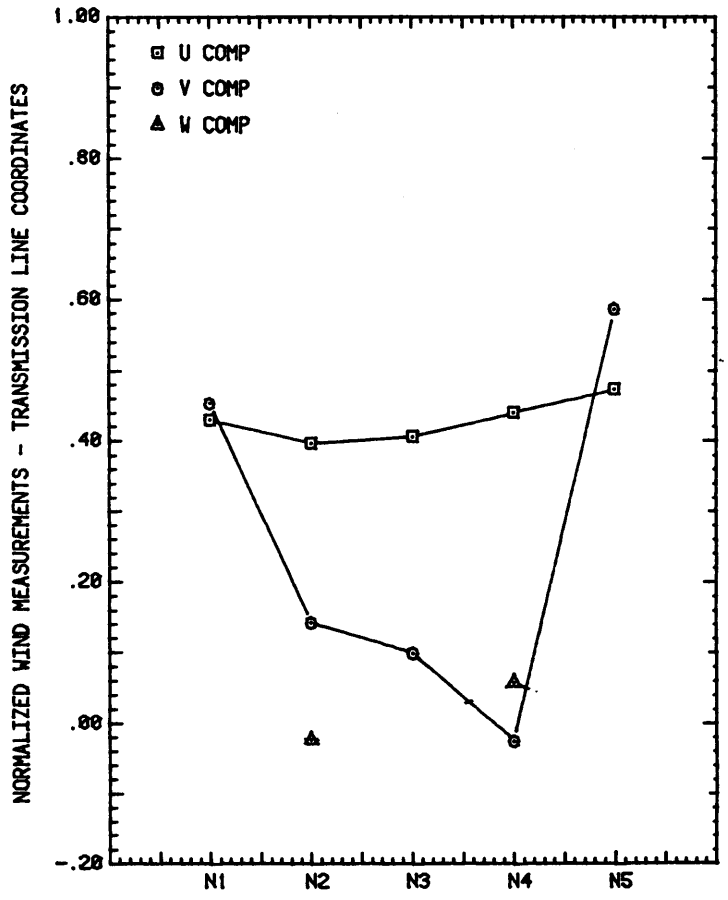


Figure F-12. Transmission line height mean speeds for Span N for the south (S) wind direction.

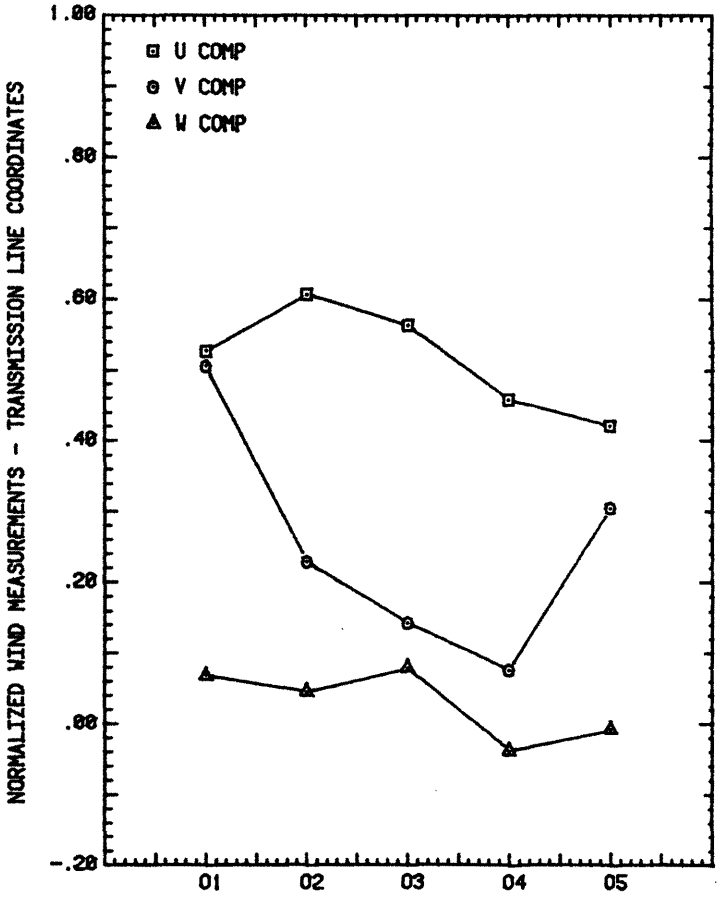


Figure F-13. Transmission line height mean speeds for Span O for the south (S) wind direction.

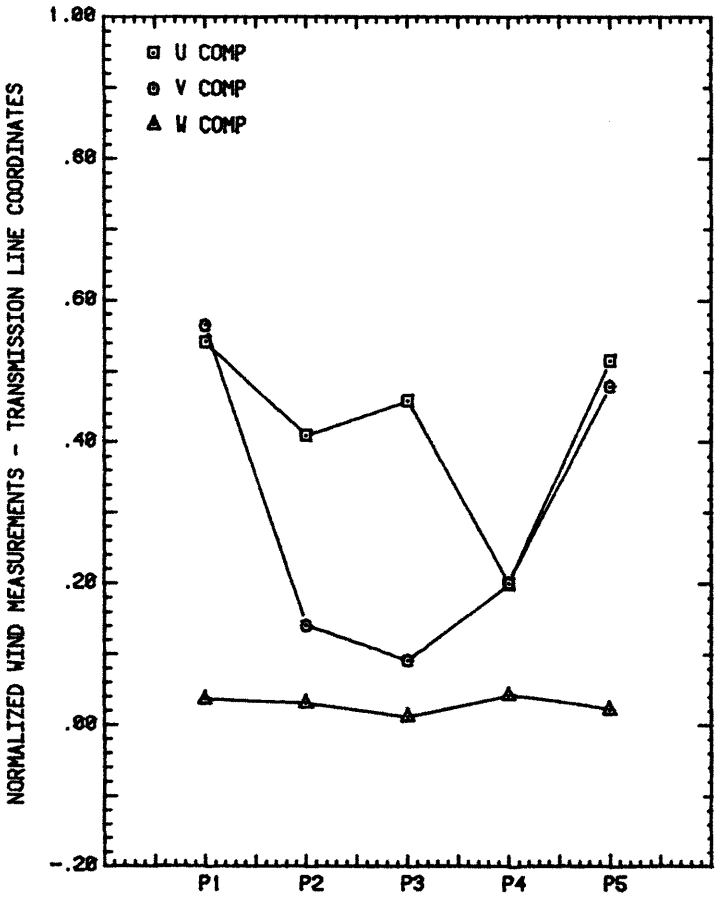


Figure F-14. Transmission line height mean speeds for Span P for the south (S) wind direction.

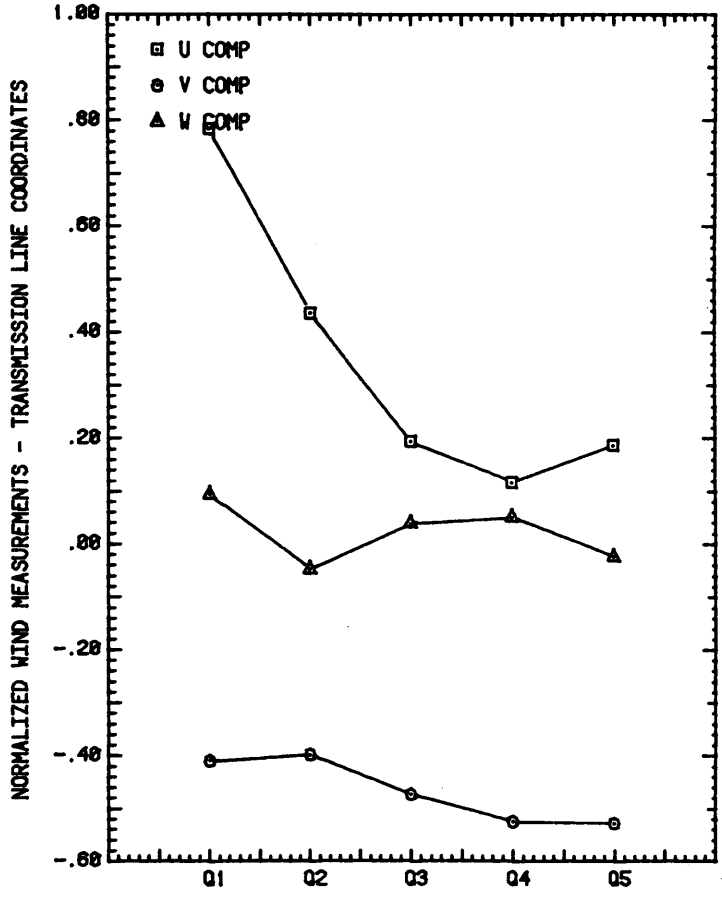


Figure F-15. Transmission line height mean speeds for Span Q for the south (S) wind direction.

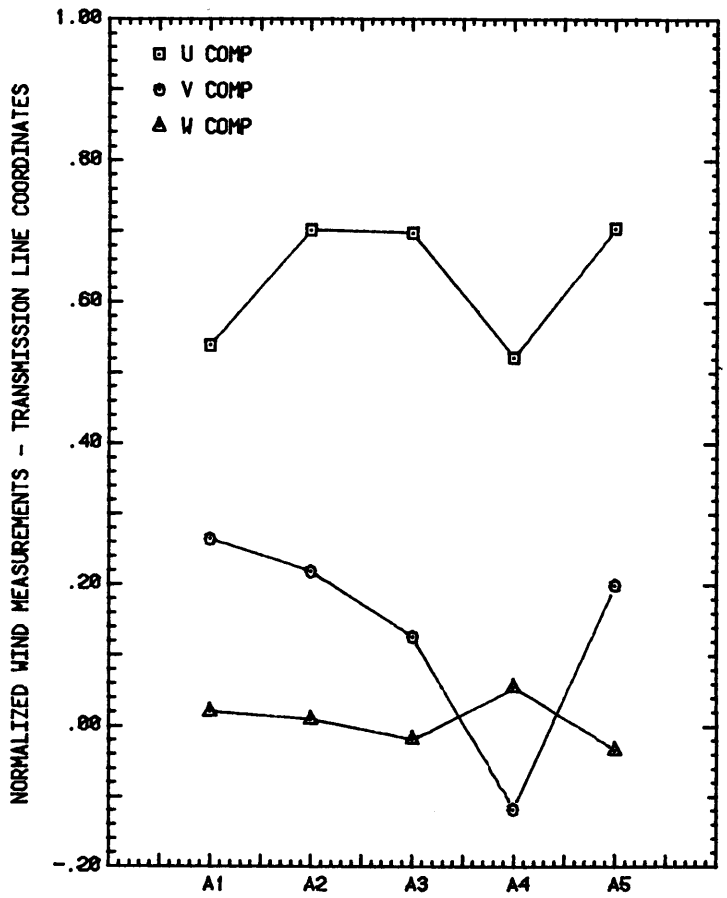


Figure F-16. Transmission line height mean speeds for Span A for the south southwest (SSW) wind direction.

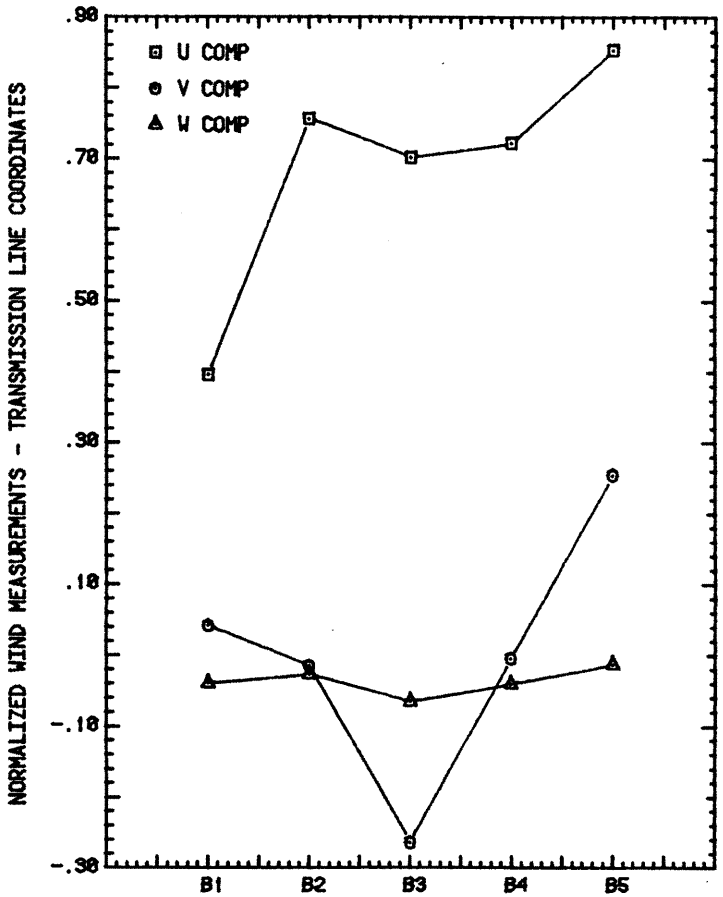


Figure F-17. Transmission line height mean speeds for Span B for the south southwest (SSW) wind direction.

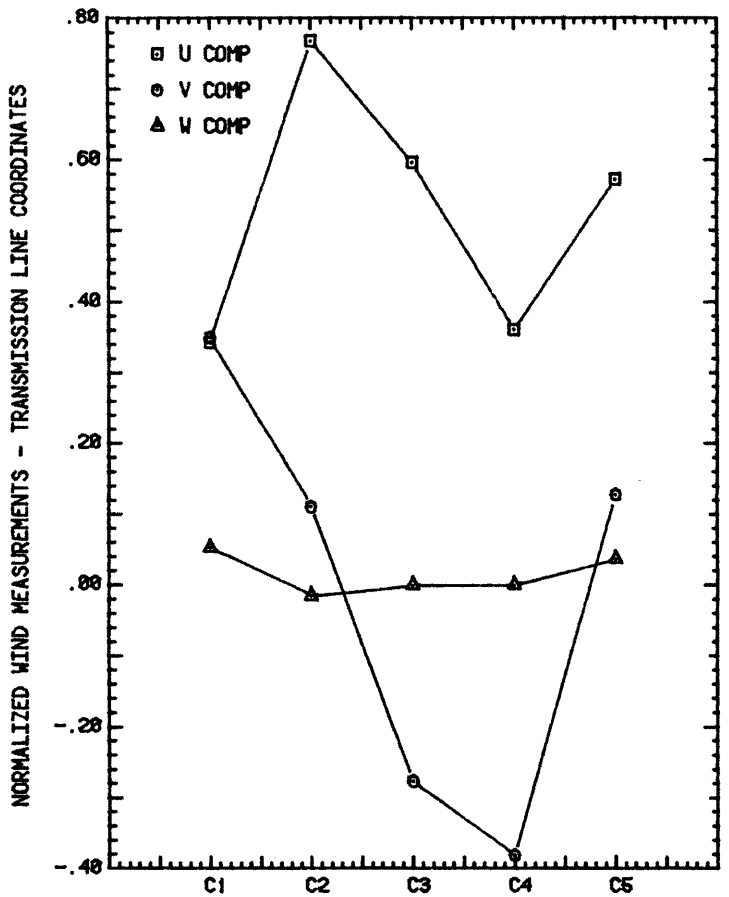


Figure F-18. Transmission line height mean speeds for Span C for the south southwest (SSW) wind direction.

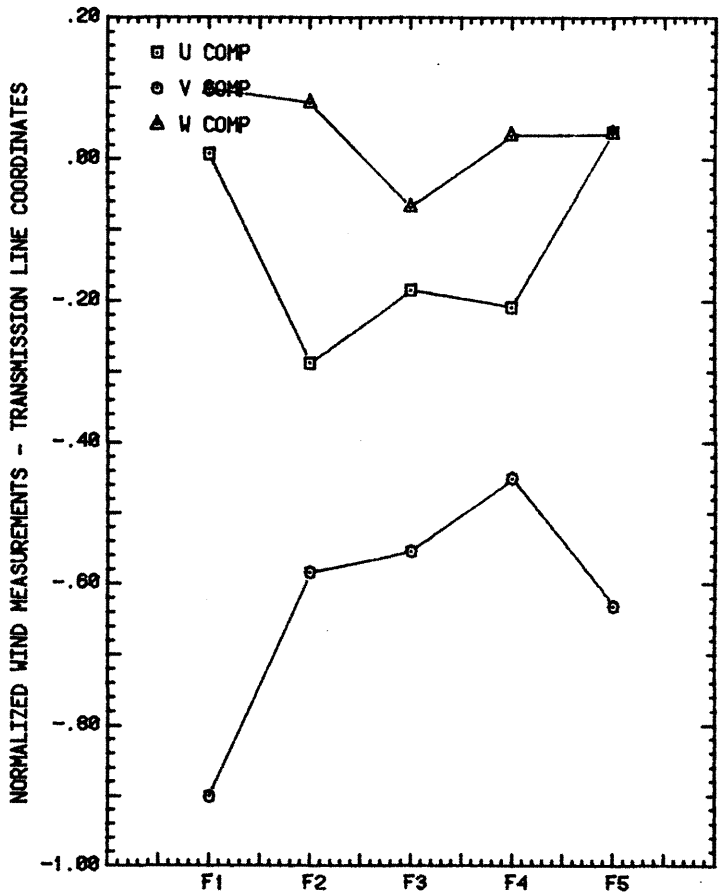


Figure F-19. Transmission line height mean speeds for Span F for the south southwest (SSW) wind direction.

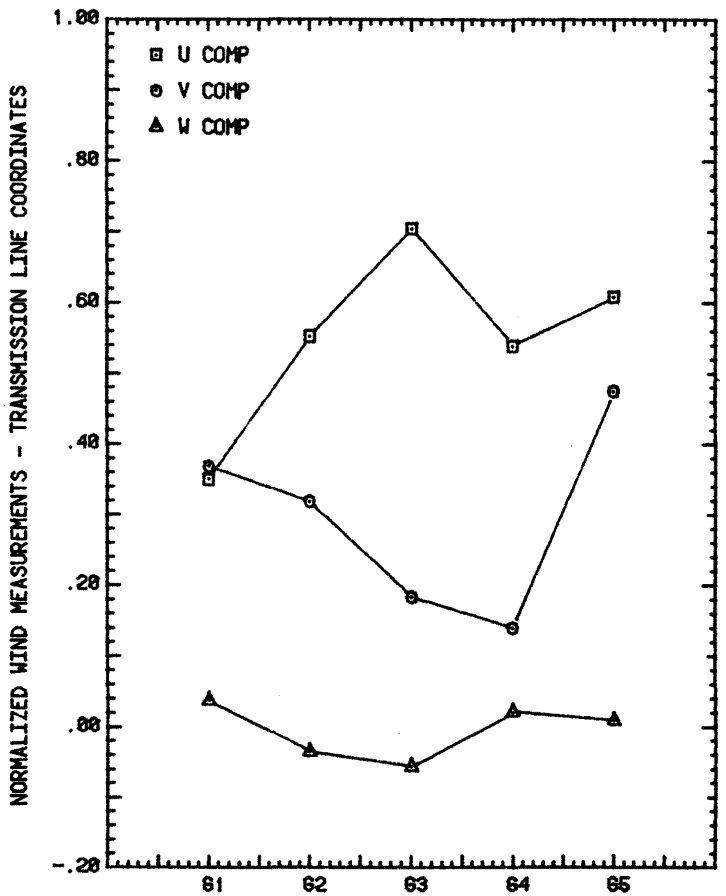


Figure F-20. Transmission line height mean speeds for Span G for the south southwest (SSW) wind direction.

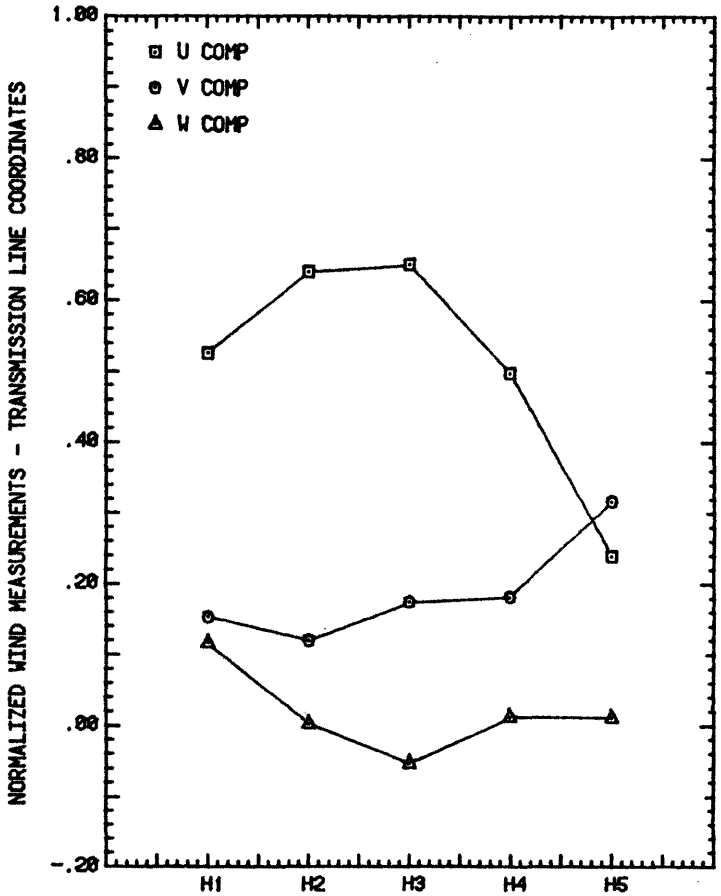


Figure F-21. Transmission line height mean speeds for Span H for the south southwest (SSW) wind direction.

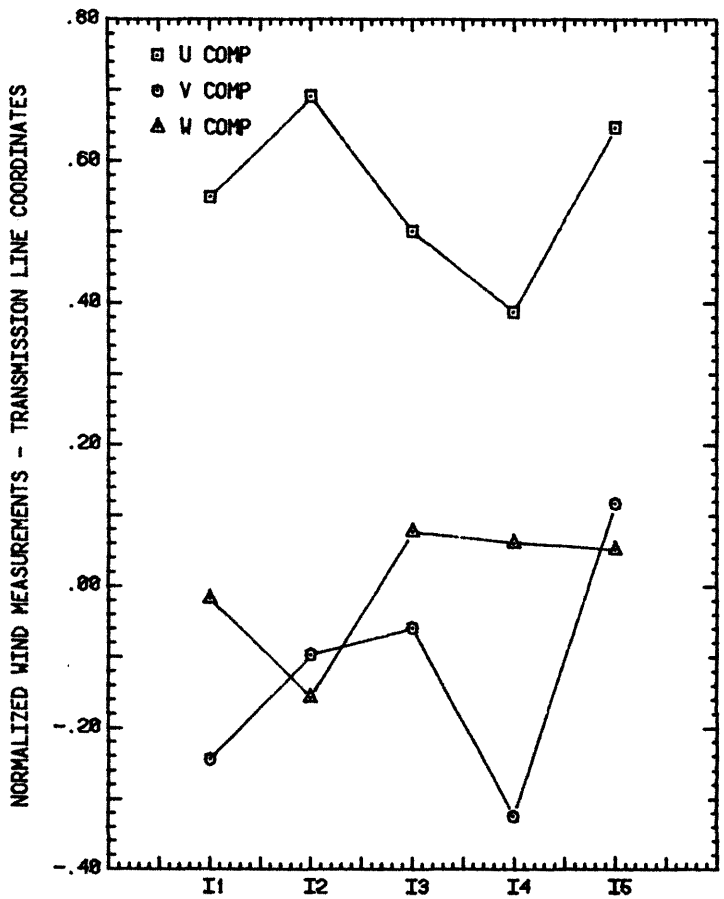


Figure F-22. Transmission line height mean speeds for Span I for the south southwest (SSW) wind direction.

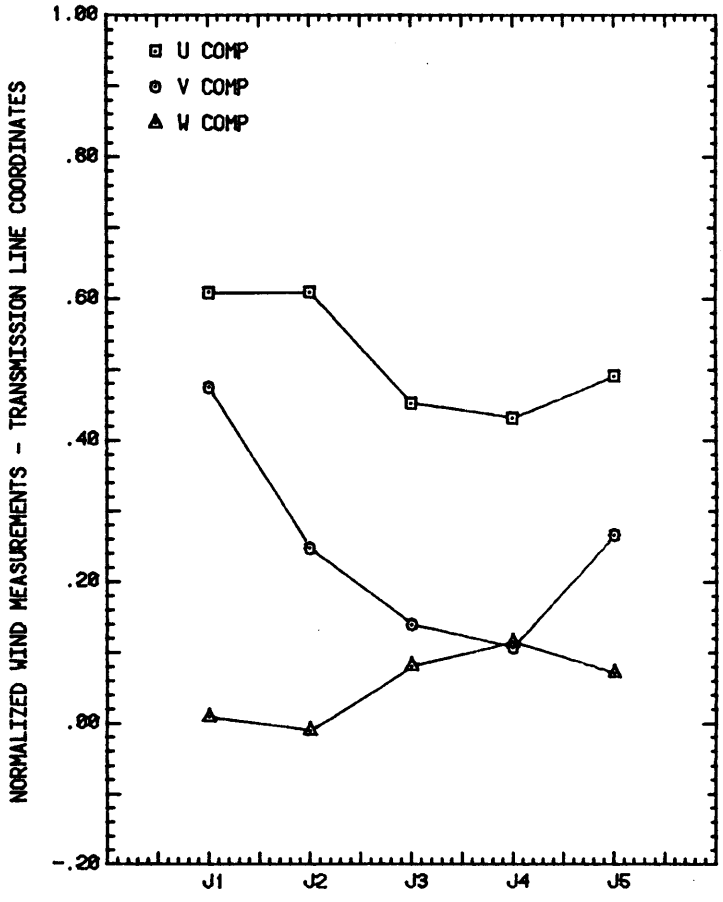


Figure F-23. Transmission line height mean speeds for Span J for the south southwest (SSW) wind direction.

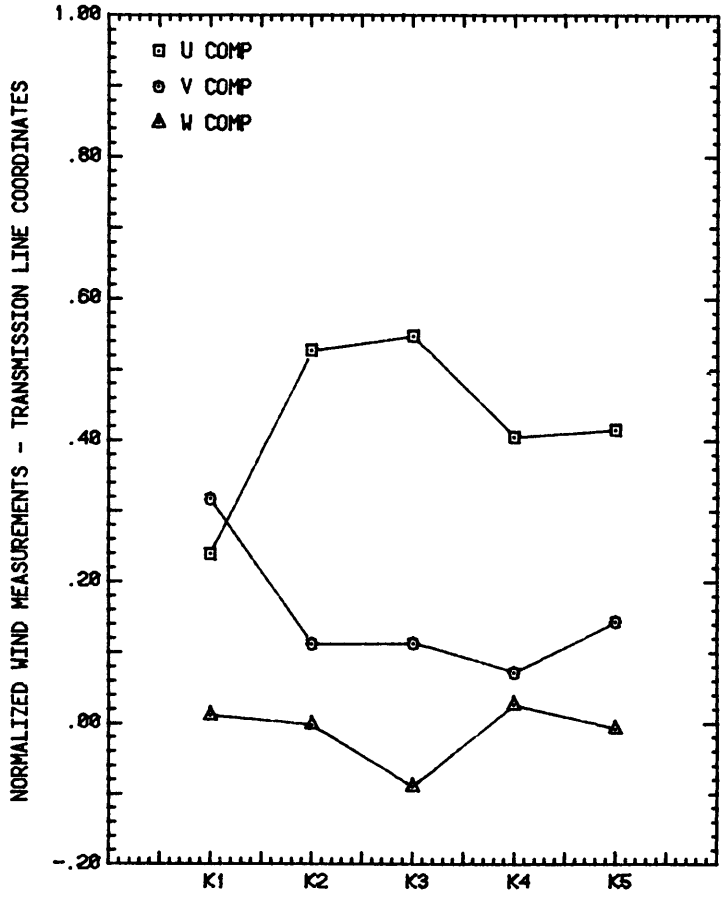


Figure F-24. Transmission line height mean speeds for Span K for the south southwest (SSW) wind direction.

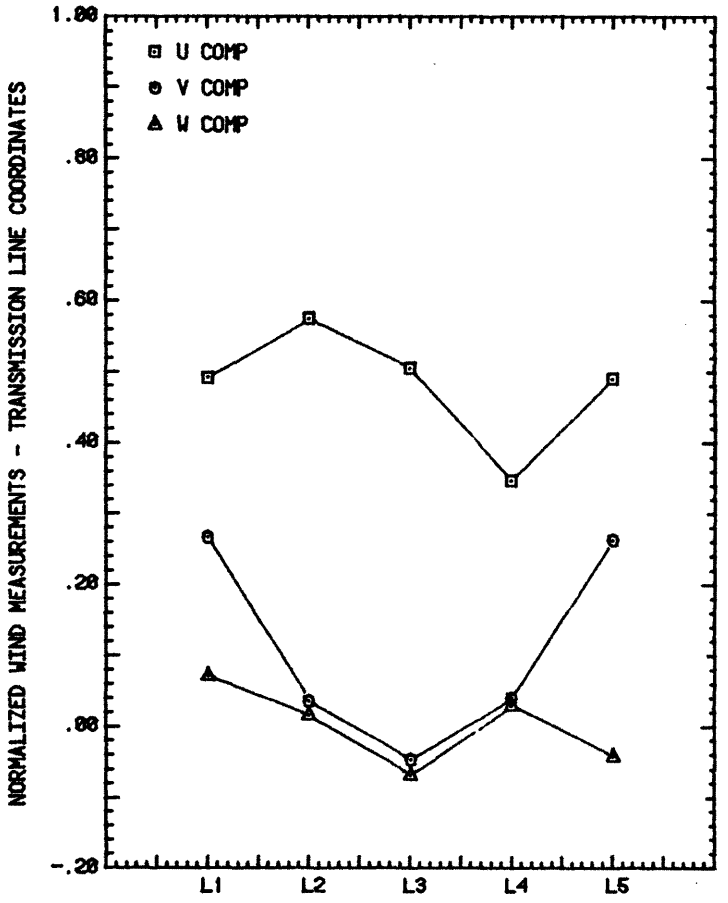


Figure F-25. Transmission line height mean speeds for Span L for the south southwest (SSW) wind direction.

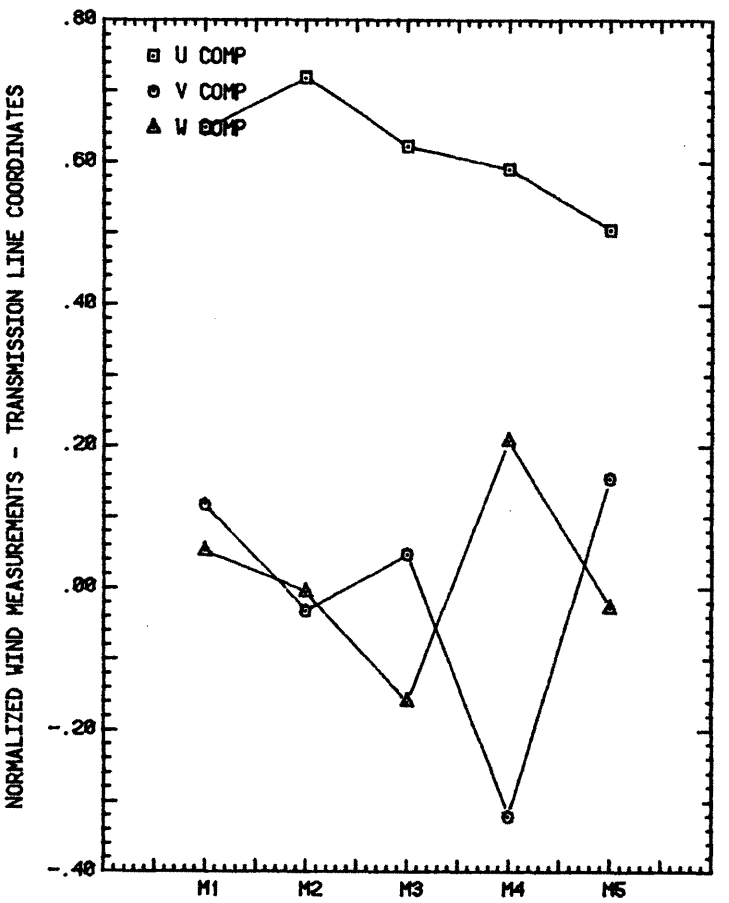


Figure F-26. Transmission line height mean speeds for Span M for the south southwest (SSW) wind direction.

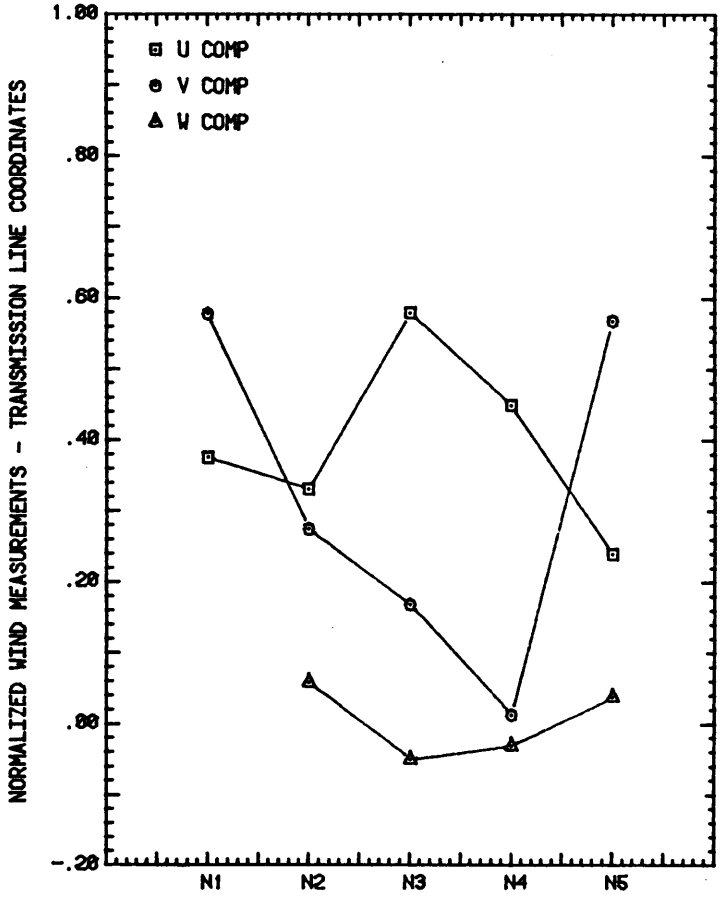


Figure F-27. Transmission line height mean speeds for Span N for the south southwest (SSW) wind direction.

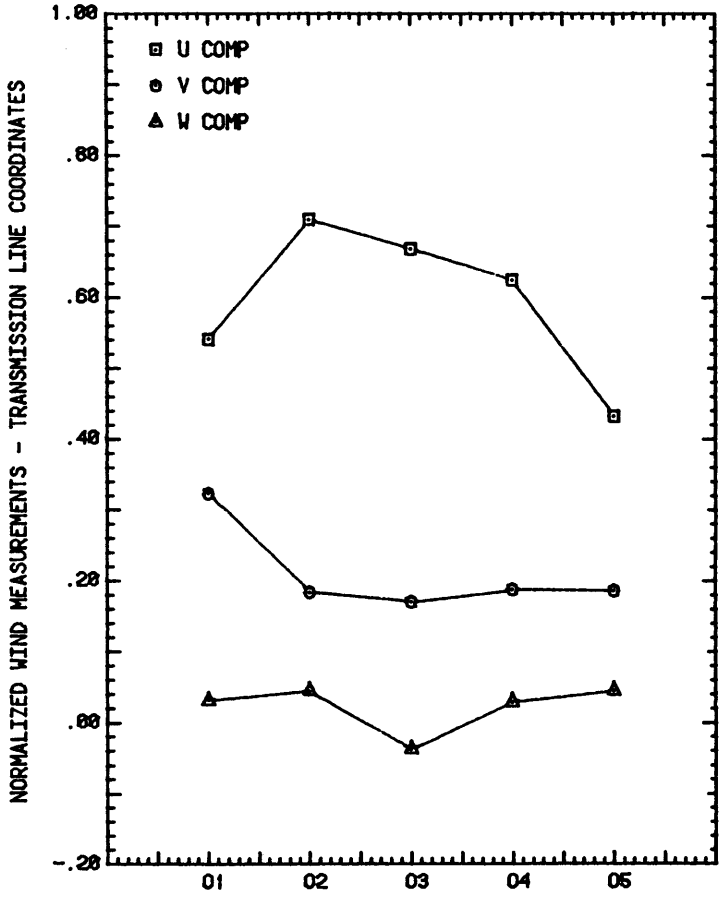


Figure F-28. Transmission line height mean speeds for Span O for the south southwest (SSW) wind direction.

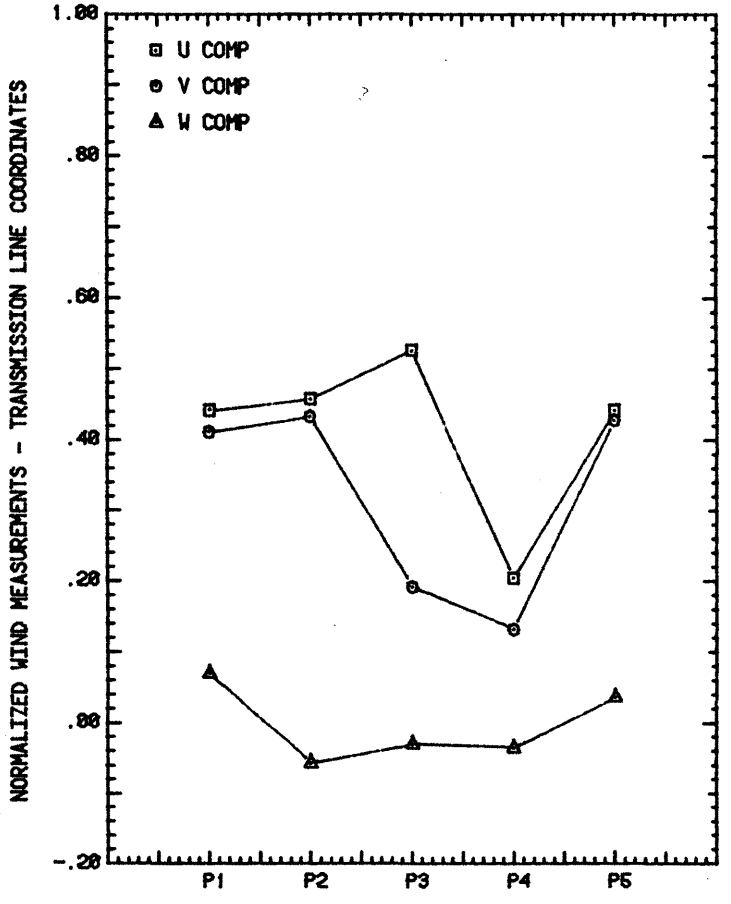


Figure F-29. Transmission line height mean speeds for Span P for the south southwest (SSW) wind direction.

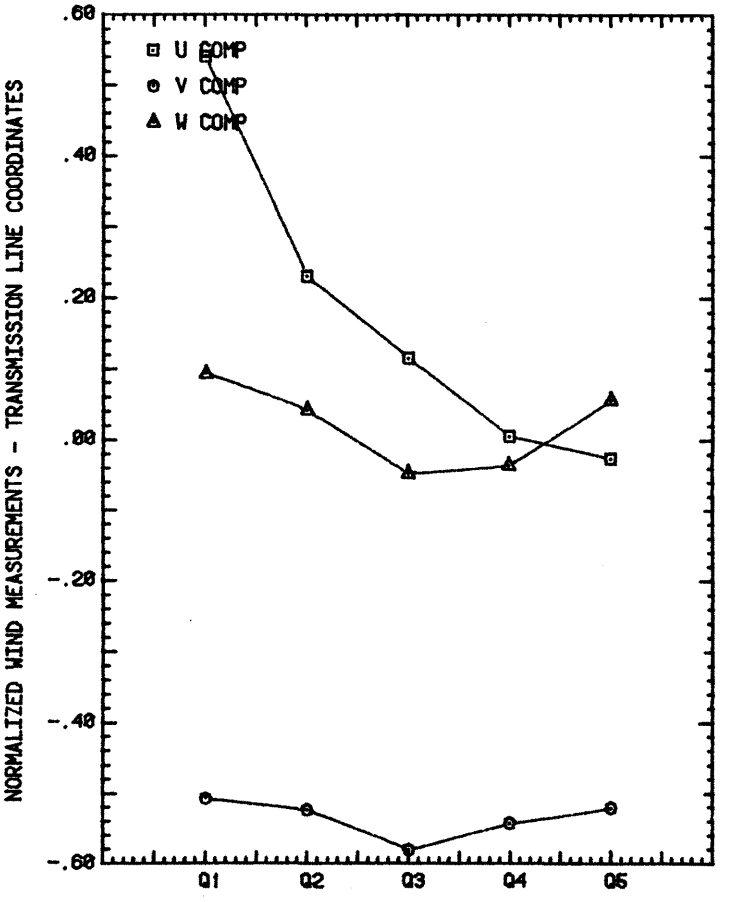


Figure F-30. Transmission line height mean speeds for Span Q for the south southwest (SSW) wind direction.

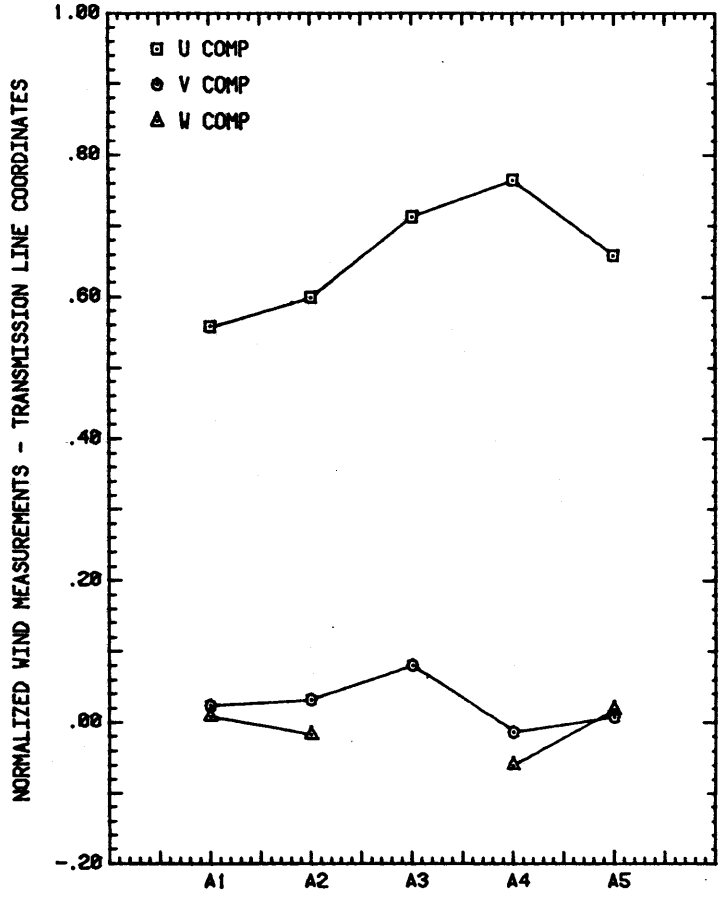


Figure F-31. Transmission line height mean speeds for Span A for the southwest (SW) wind direction.

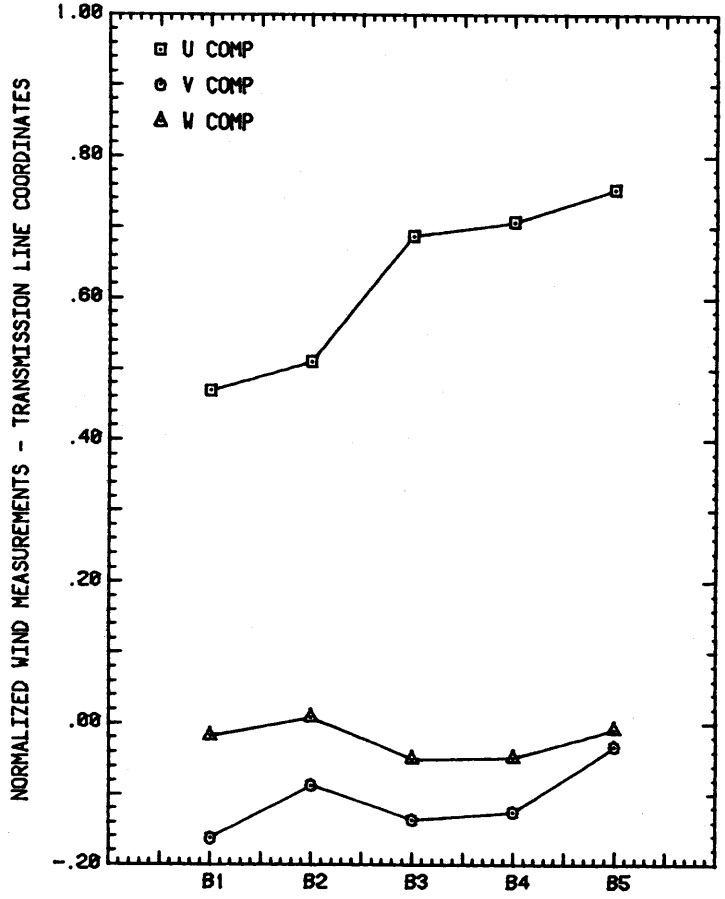


Figure F-32. Transmission line height mean speeds for Span B for the southwest (SW) wind direction.

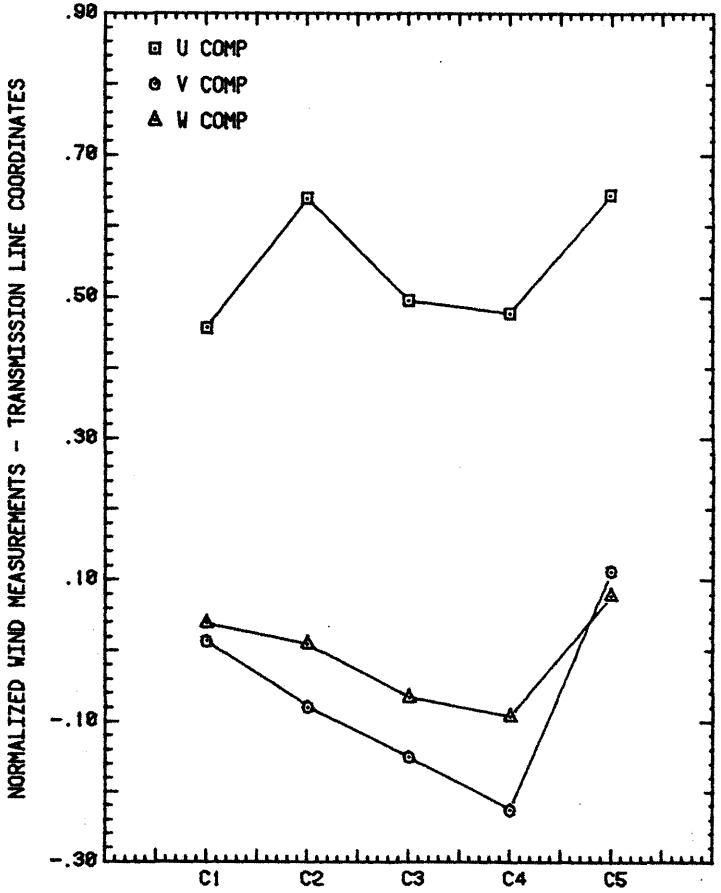


Figure F-33. Transmission line height mean speeds for Span C for the southwest (SW) wind direction.

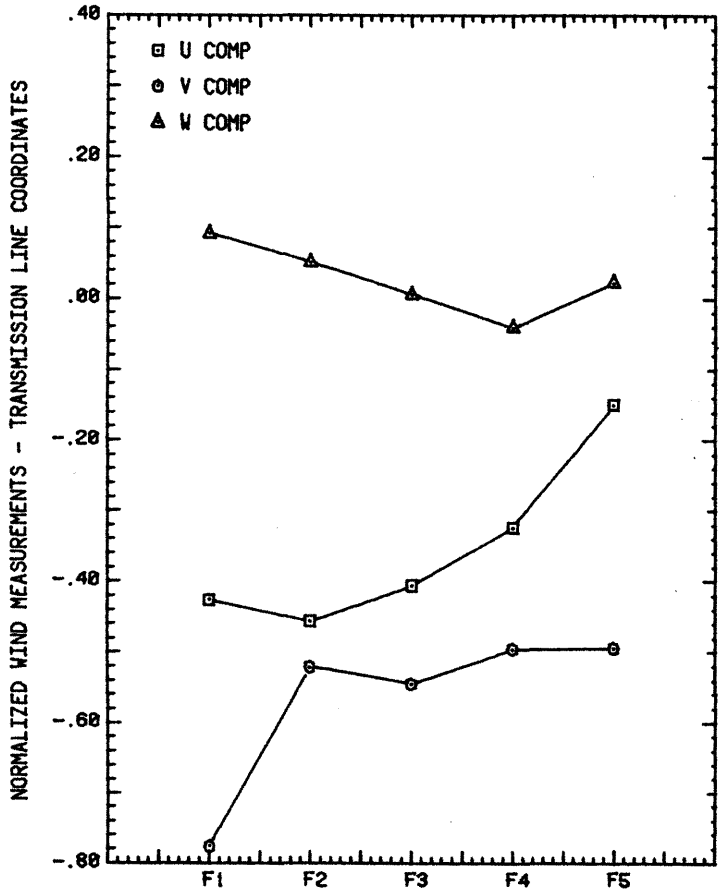


Figure F-34. Transmission line height mean speeds for Span F for the southwest (SW) wind direction.

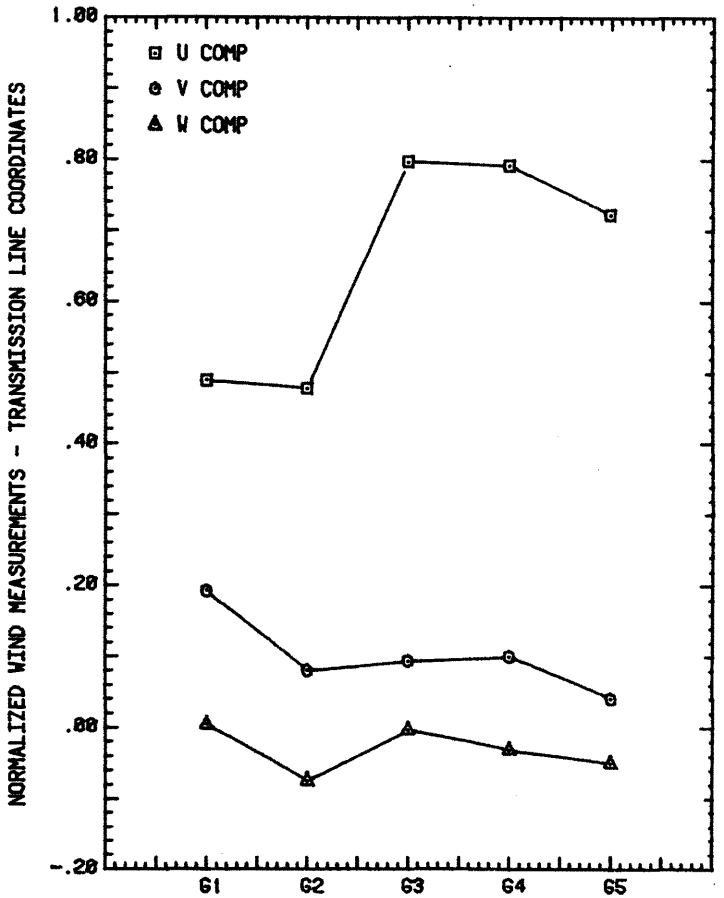


Figure F-35. Transmission line height mean speeds for Span G for the southwest (SW) wind direction.

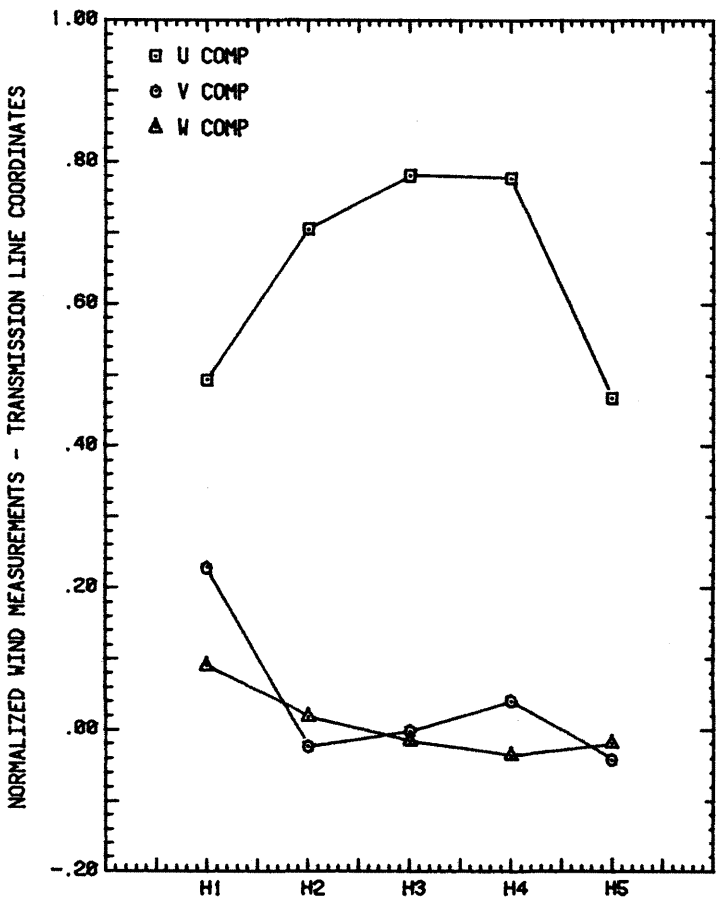


Figure F-36. Transmission line height mean speeds for Span H for the southwest (SW) wind direction.

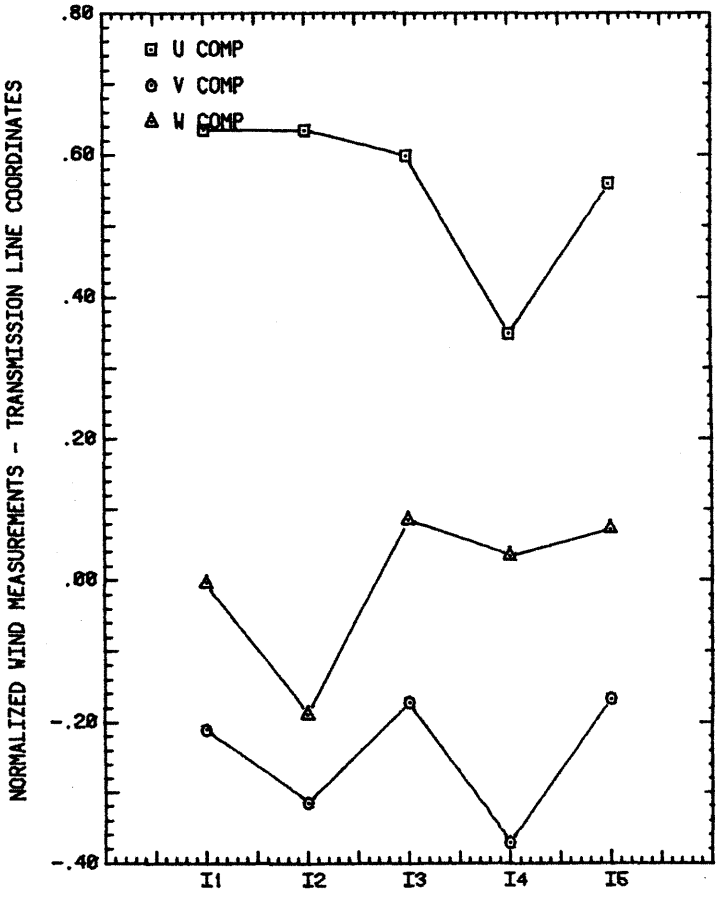


Figure F-37. Transmission line height mean speeds for Span I for the southwest (SW) wind direction.

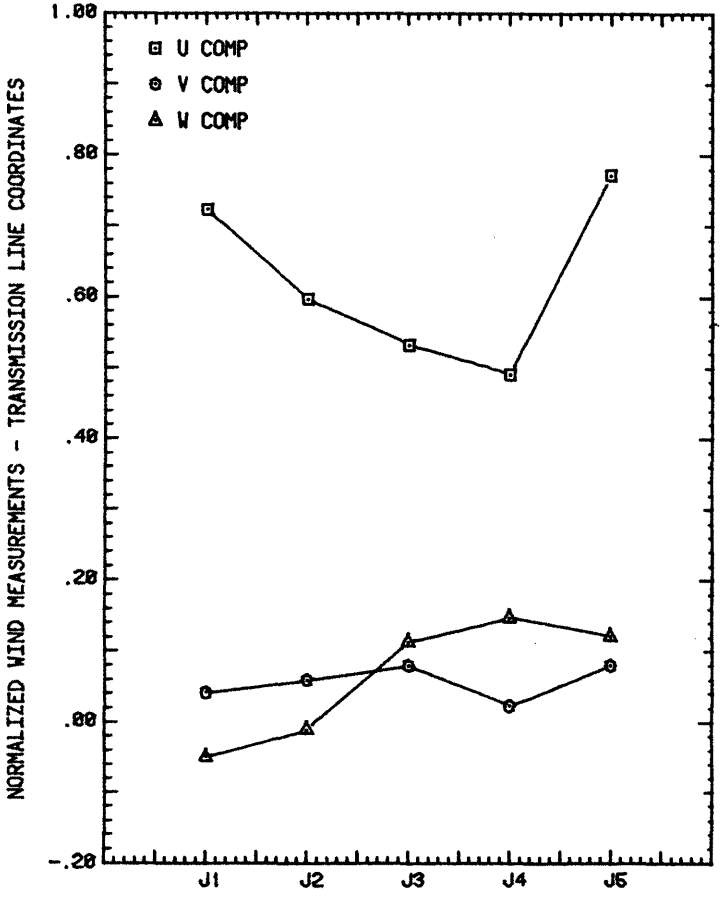


Figure F-38. Transmission line height mean speeds for Span J for the southwest (SW) wind direction.

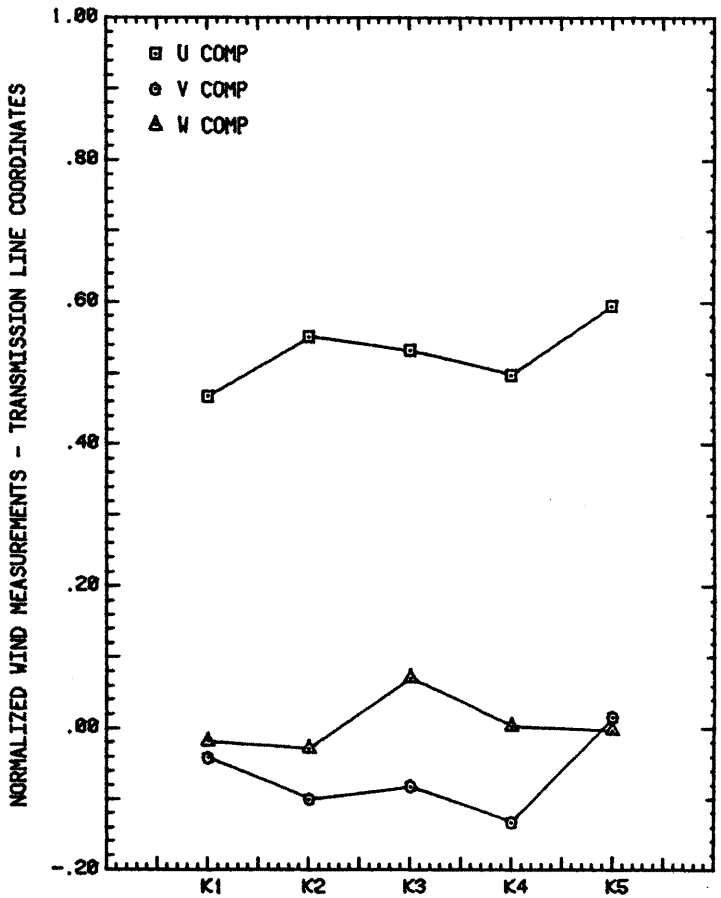


Figure F-39. Transmission line height mean speeds for Span K for the southwest (SW) wind direction.

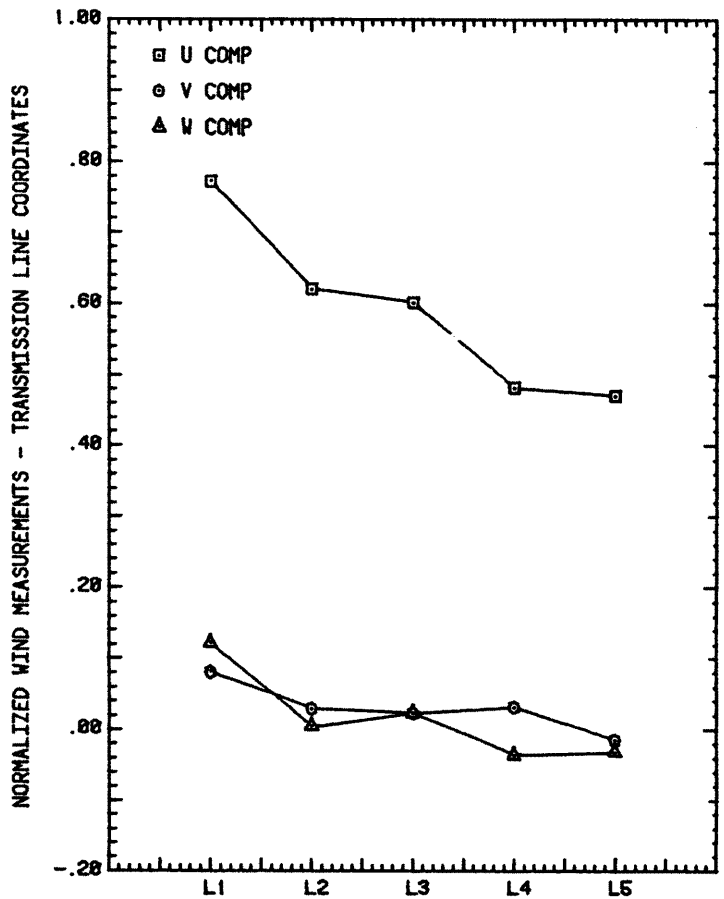


Figure F-40. Transmission line height mean speeds for Span L for the southwest (SW) wind direction.

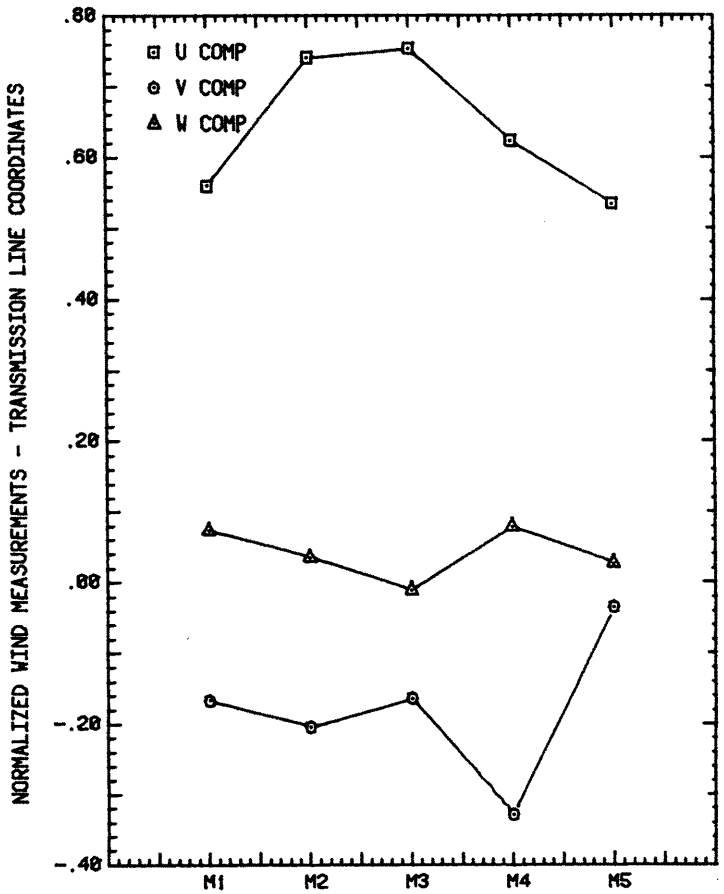


Figure F-41. Transmission line height mean speeds for Span M for the southwest (SW) wind direction.

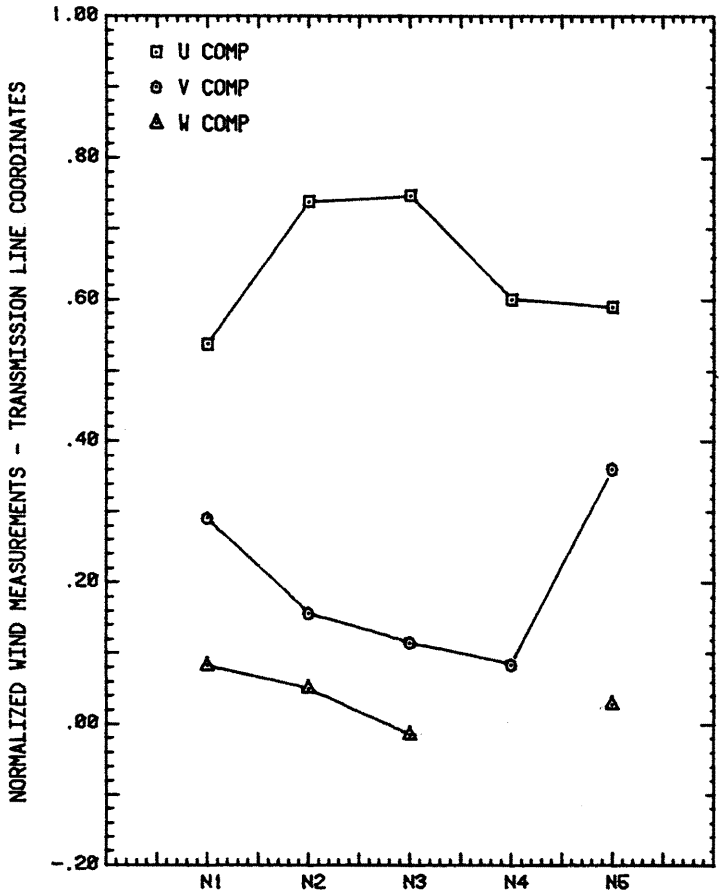


Figure F-42. Transmission line height mean speeds for Span N for the southwest (SW) wind direction.

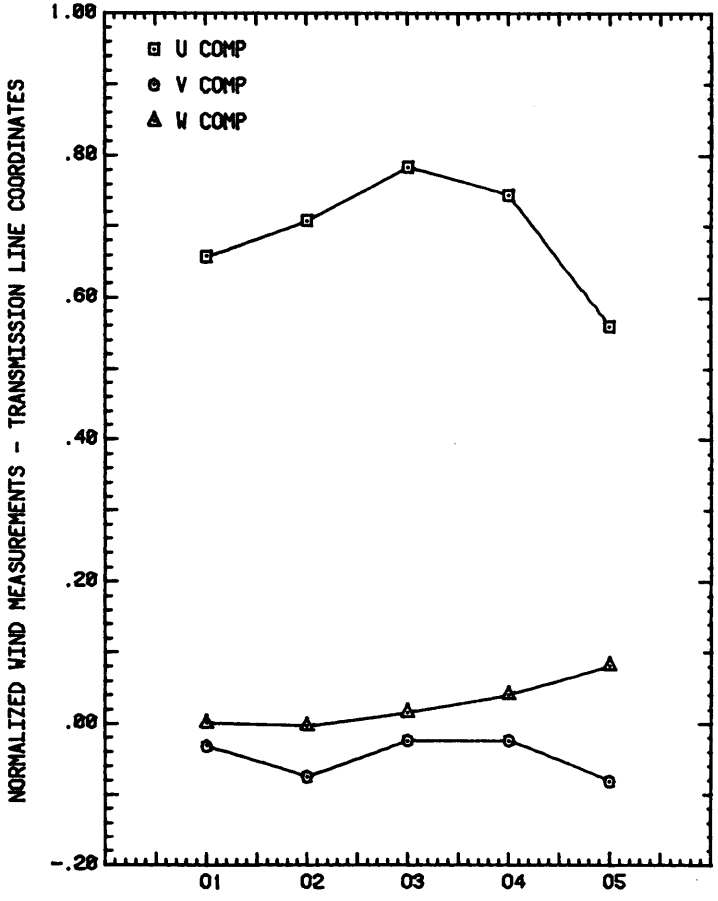


Figure F-43. Transmission line height mean speeds for Span O for the southwest (SW) wind direction.

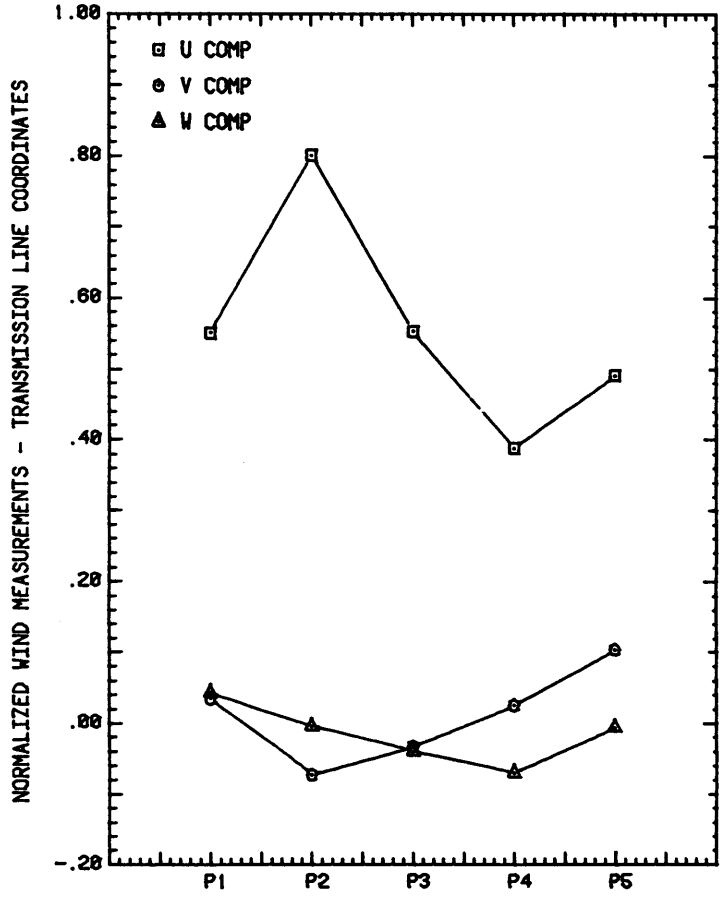


Figure F-44. Transmission line height mean speeds for Span P for the southwest (SW) wind direction.

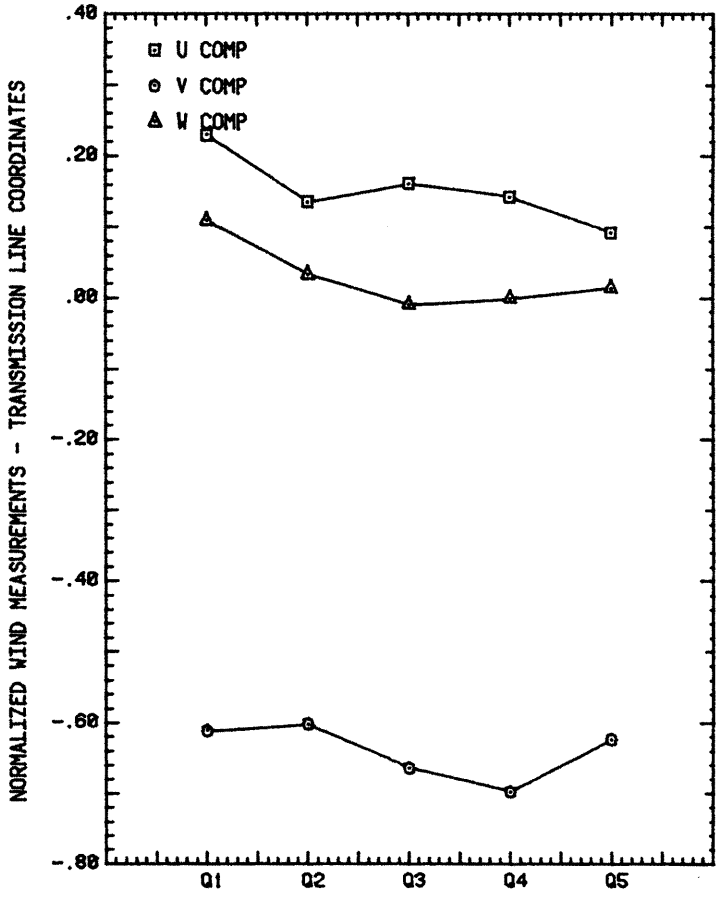


Figure F-45. Transmission line height mean speeds for Span Q for the southwest (SW) wind direction.

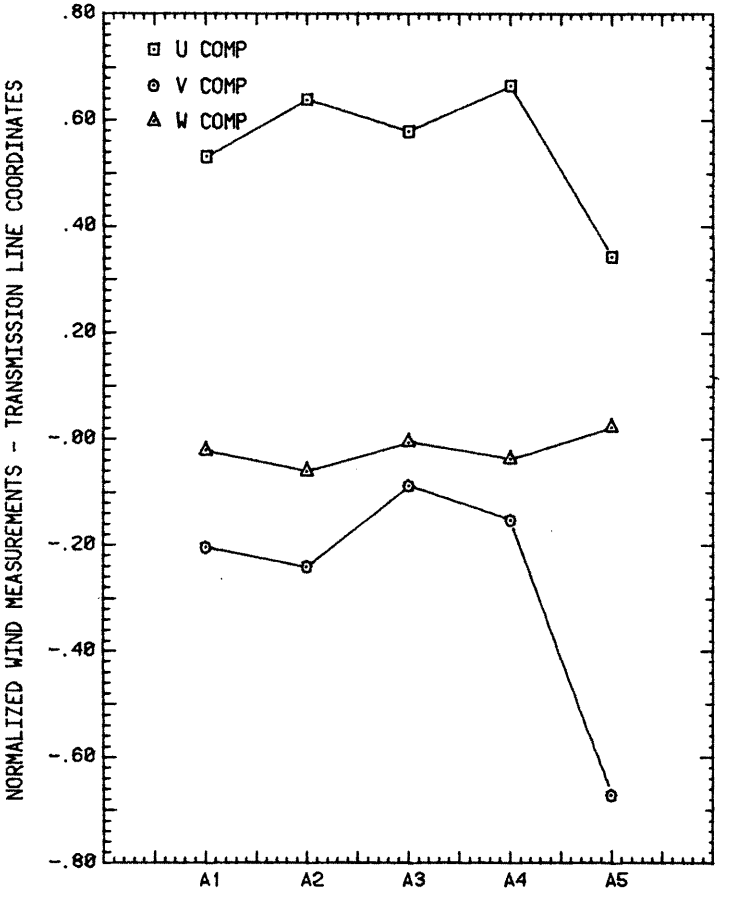


Figure F-46. Transmission line height mean speeds for Span A for the west southwest (WSW) wind direction.

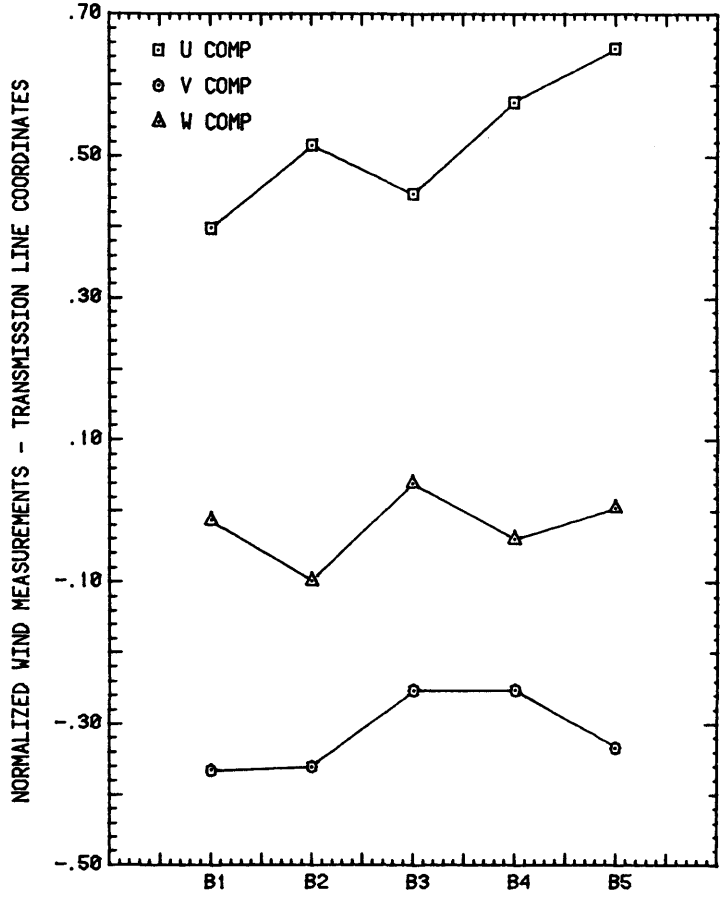


Figure F-47. Transmission line height mean speeds for Span B for the west southwest (WSW) wind direction.

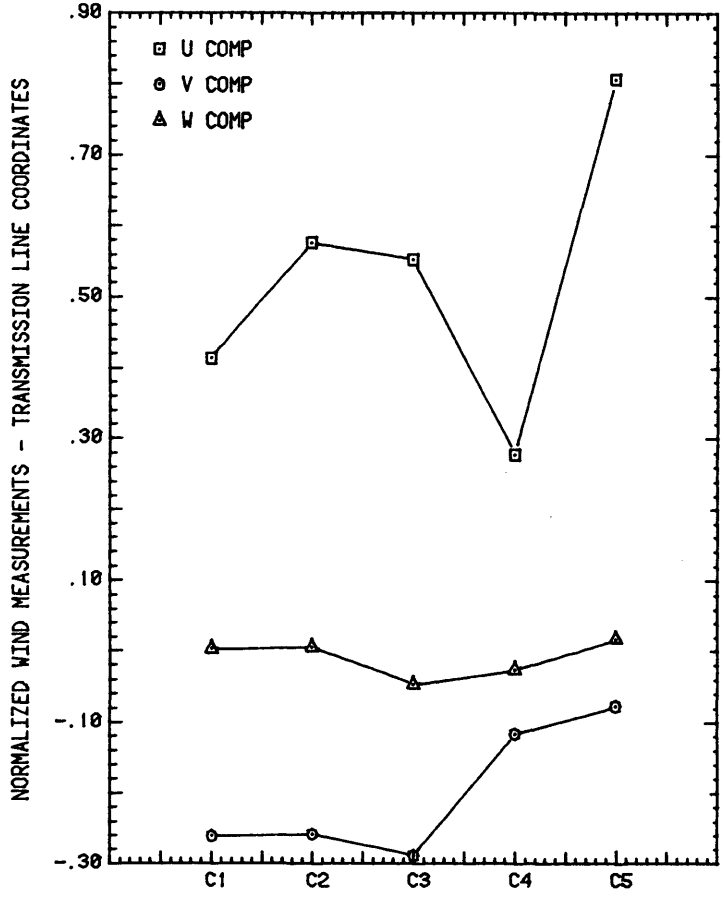


Figure F-48. Transmission line height mean speeds for Span C for the west southwest (WSW) wind direction.

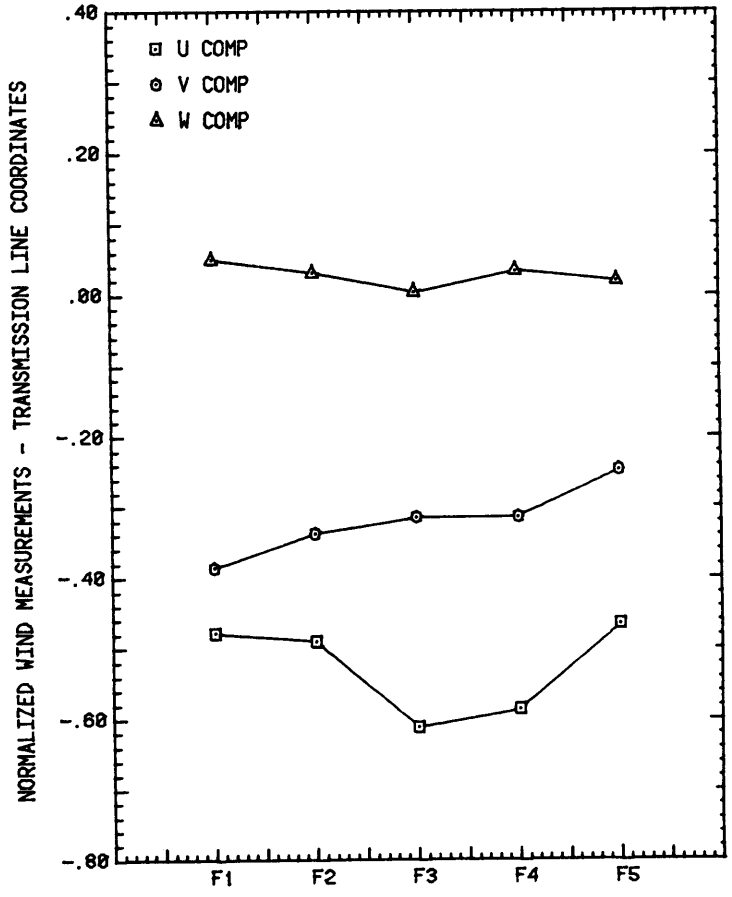


Figure F-49. Transmission line height mean speeds for Span F for the west southwest (WSW) wind direction.

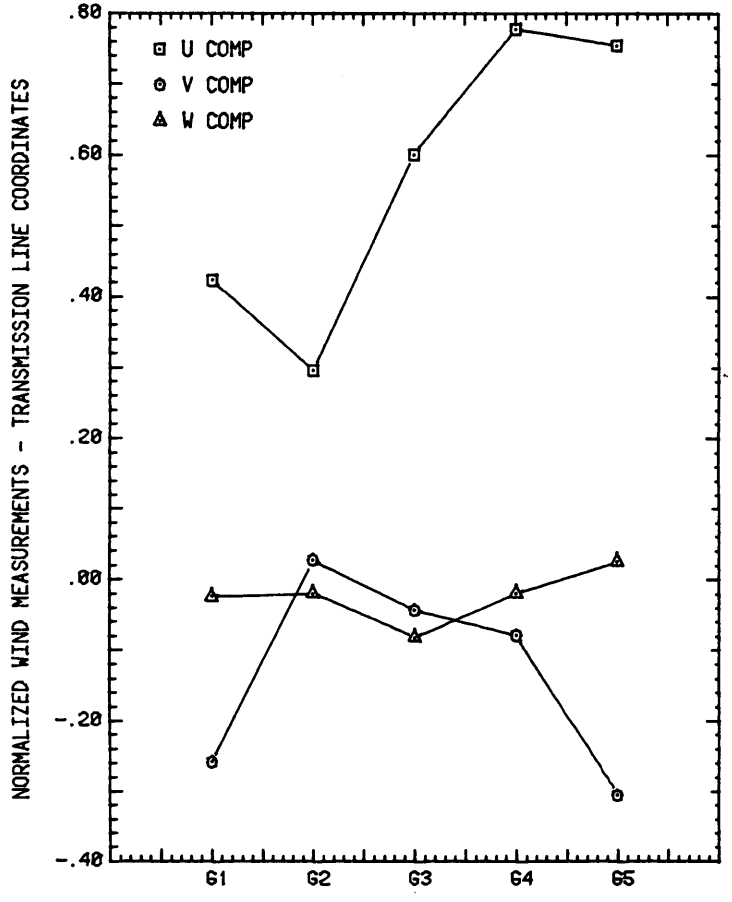


Figure F-50. Transmission line height mean speeds for Span G for the west southwest (WSW) wind direction.

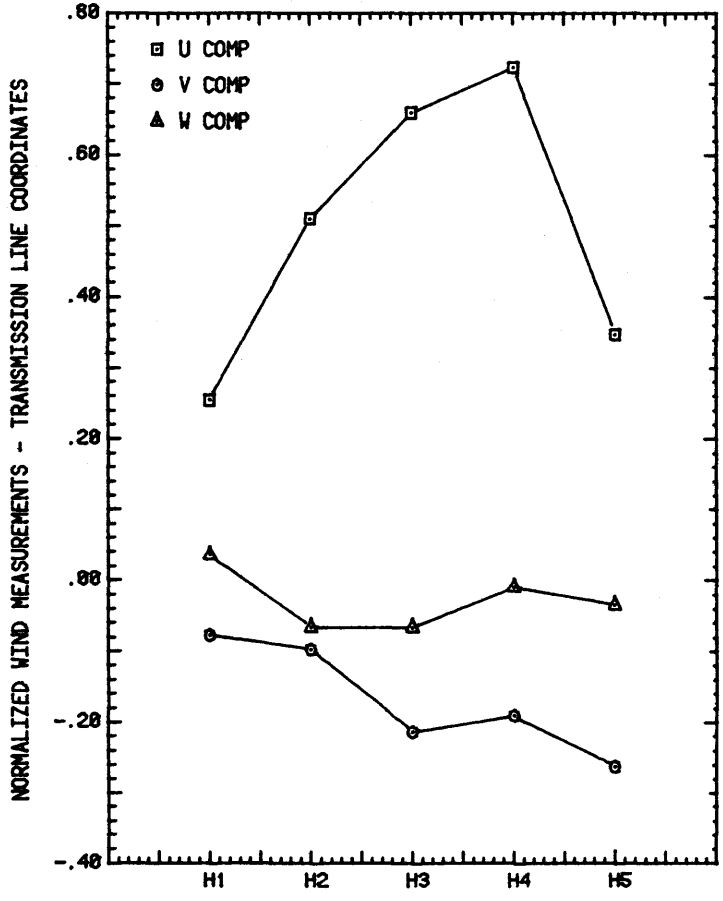


Figure F-51. Transmission line height mean speeds for Span H for the west southwest (WSW) wind direction.

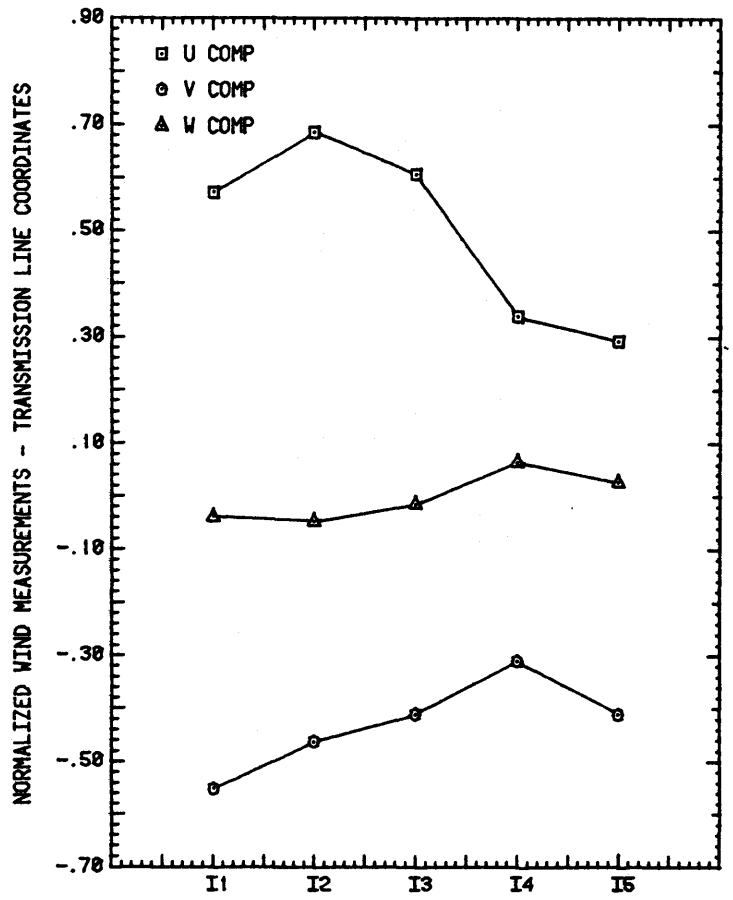


Figure F-52. Transmission line height mean speeds for Span I for the west southwest (WSW) wind direction.

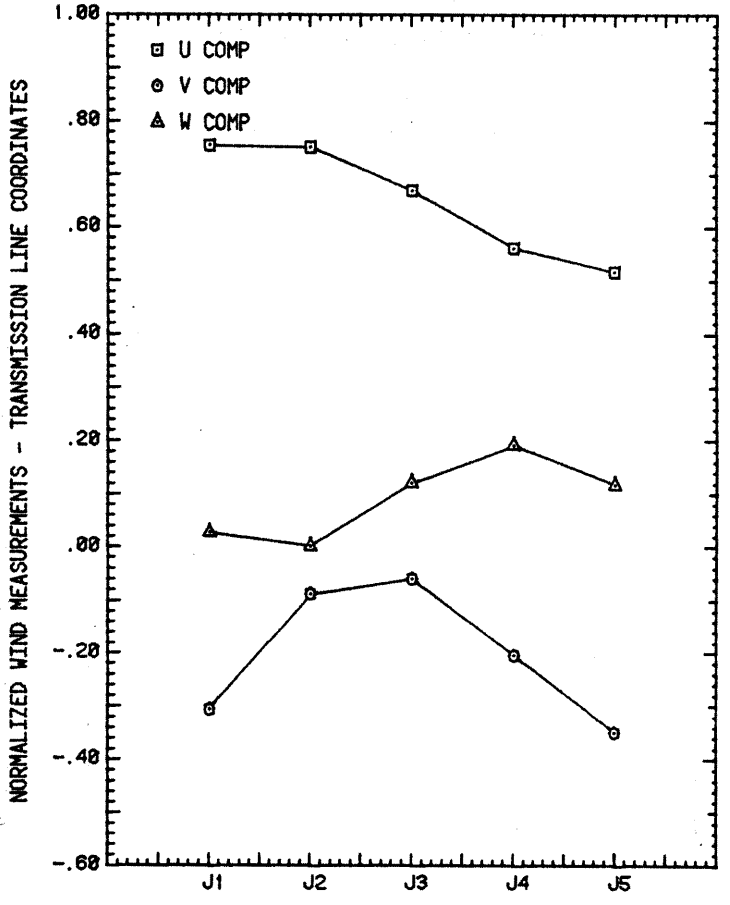


Figure F-53. Transmission line height mean speeds for Span J for the west southwest (WSW) wind direction.

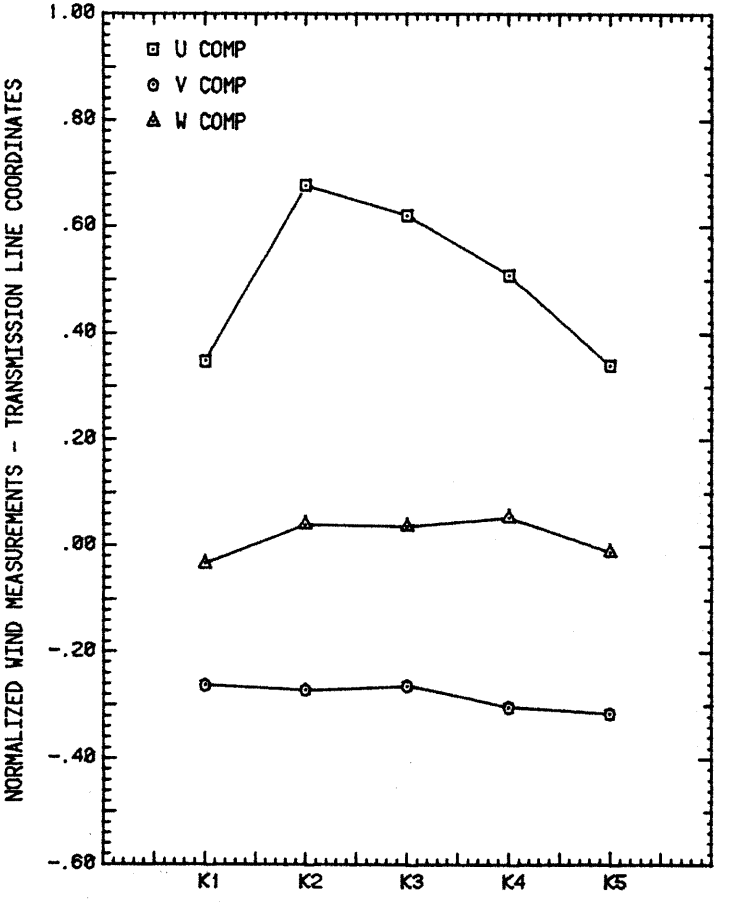


Figure F-54. Transmission line height mean speeds for Span K for the west southwest (WSW) wind direction.

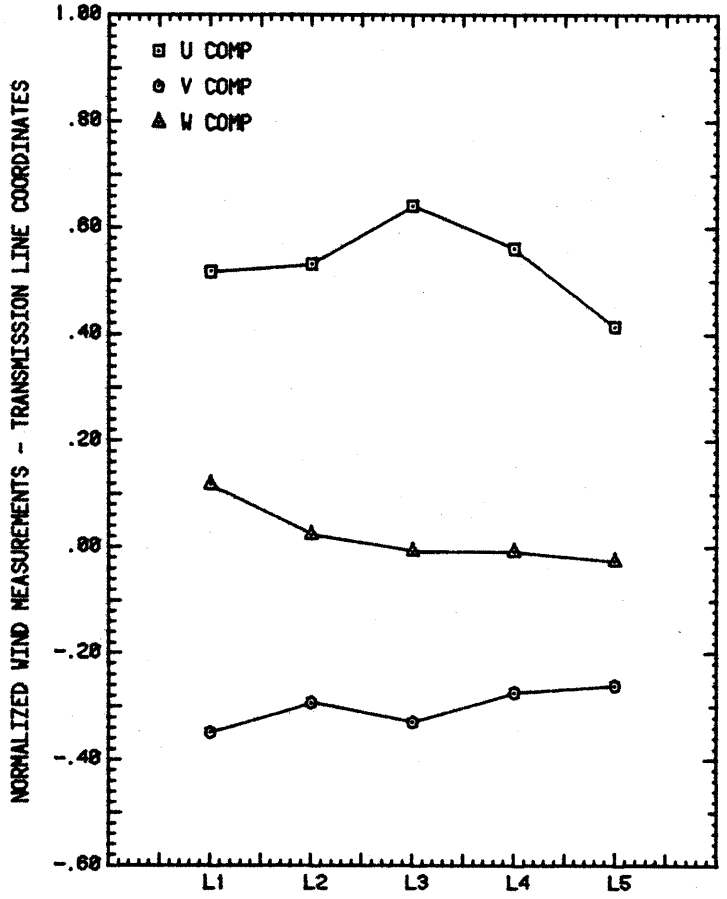


Figure F-55. Transmission line height mean speeds for Span L for the west southwest (WSW) wind direction.

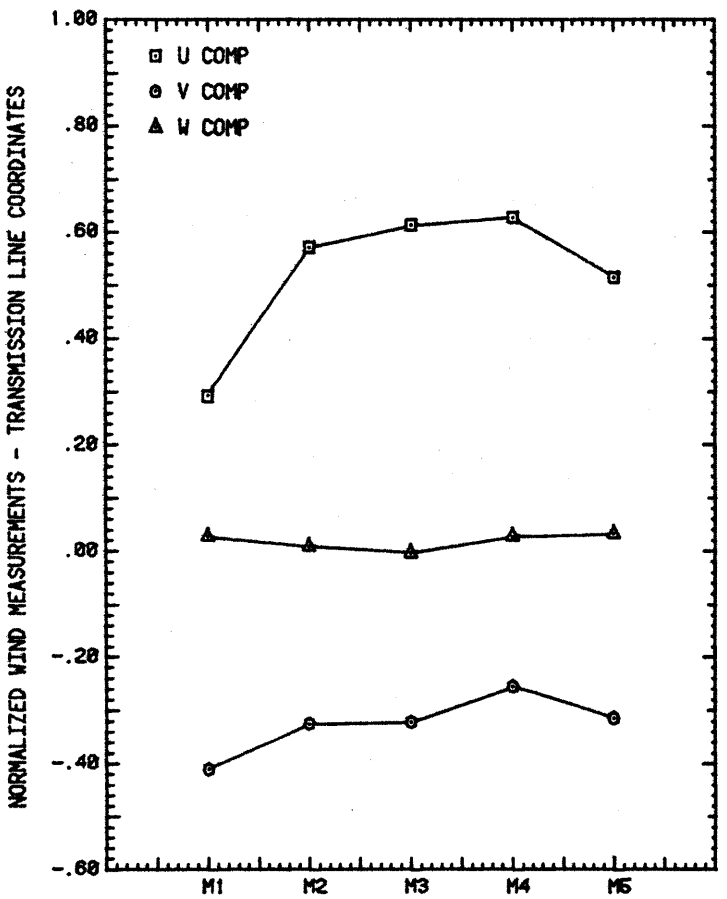


Figure F-56. Transmission line height mean speeds for Span M for the west southwest (WSW) wind direction.

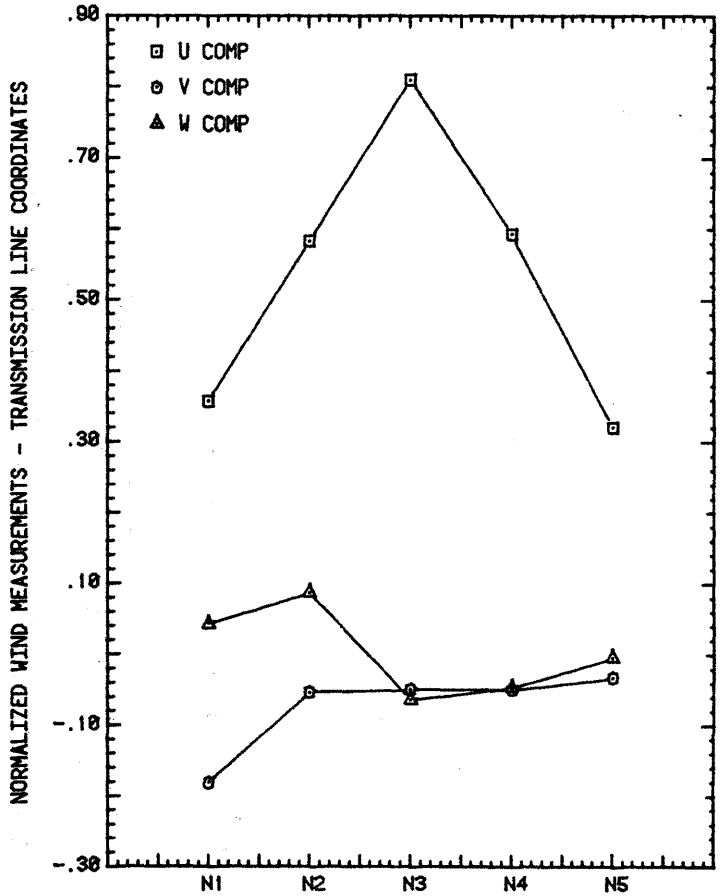


Figure F-57. Transmission line height mean speeds for Span N for the west southwest (WSW) wind direction.

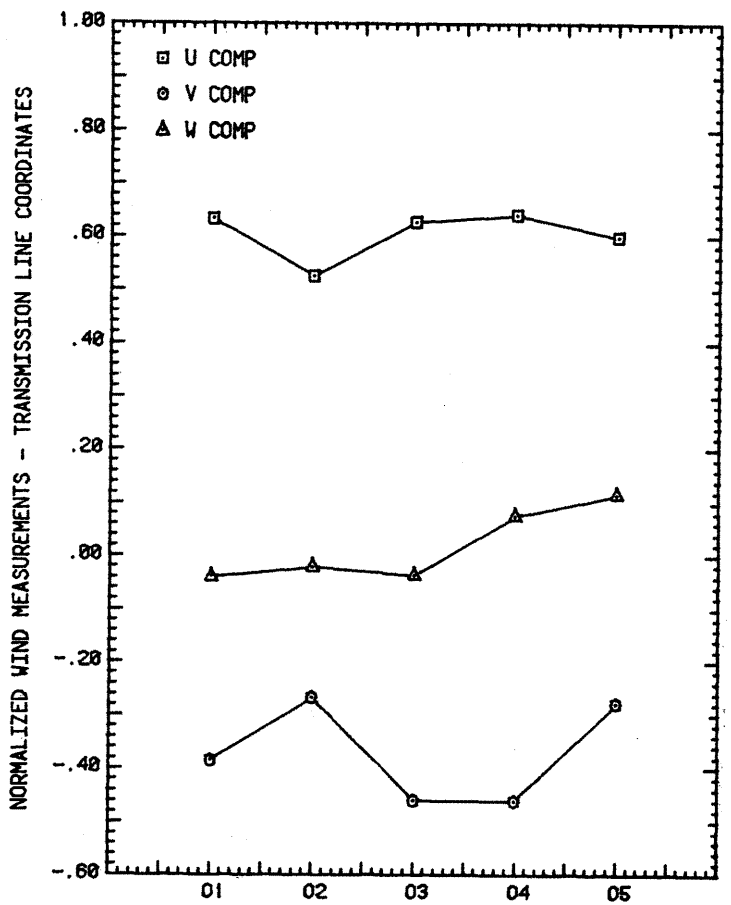


Figure F-58. Transmission line height mean speeds for Span O for the west southwest (WSW) wind direction.

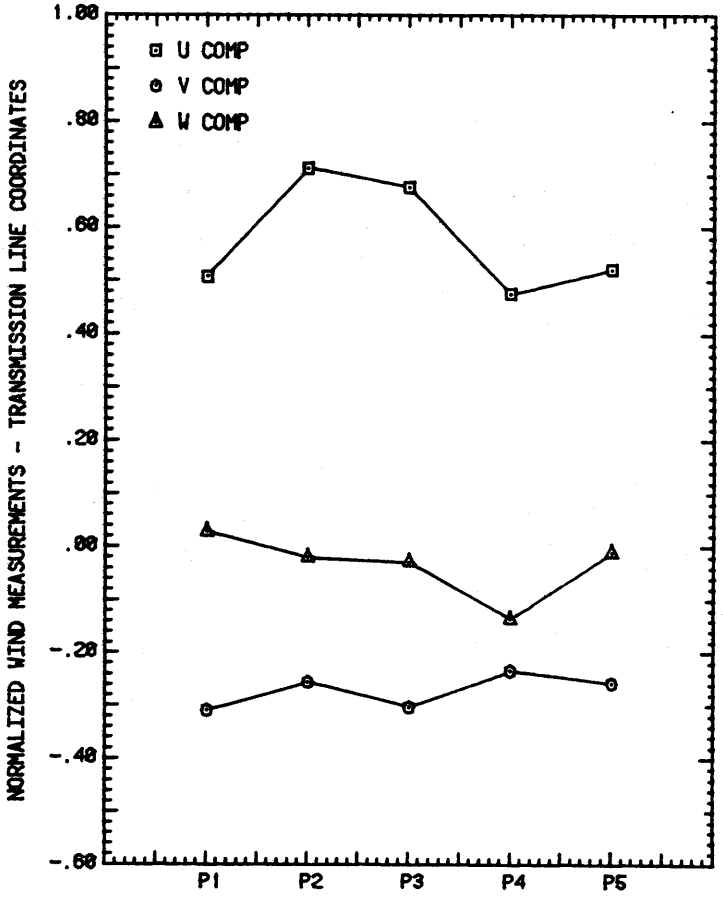


Figure F-59. Transmission line height mean speeds for Span P for the west southwest (WSW) wind direction.

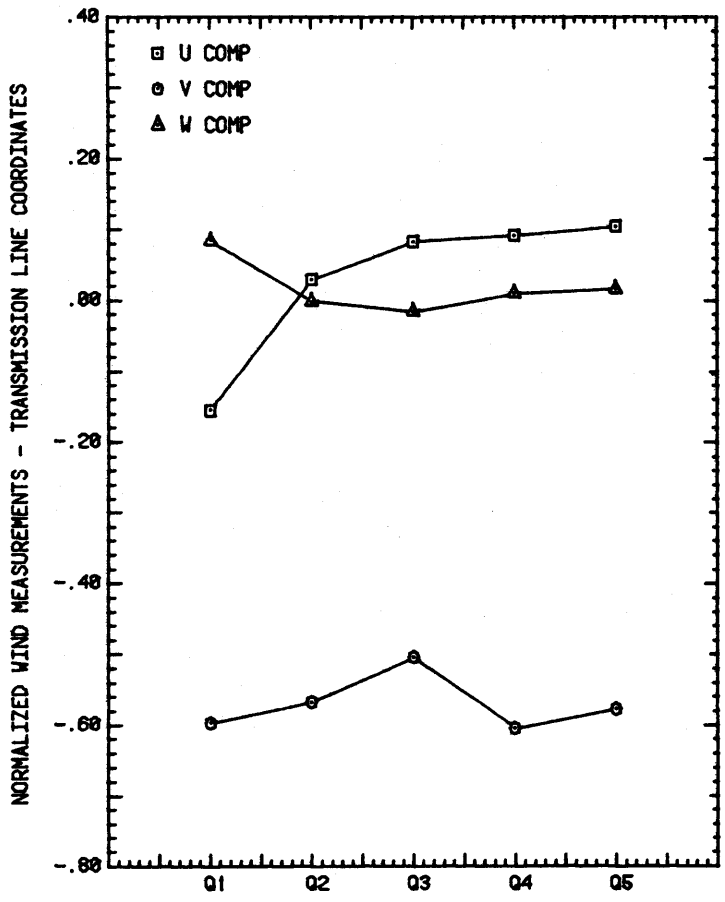


Figure F-60. Transmission line height mean speeds for Span Q for the west southwest (WSW) wind direction.

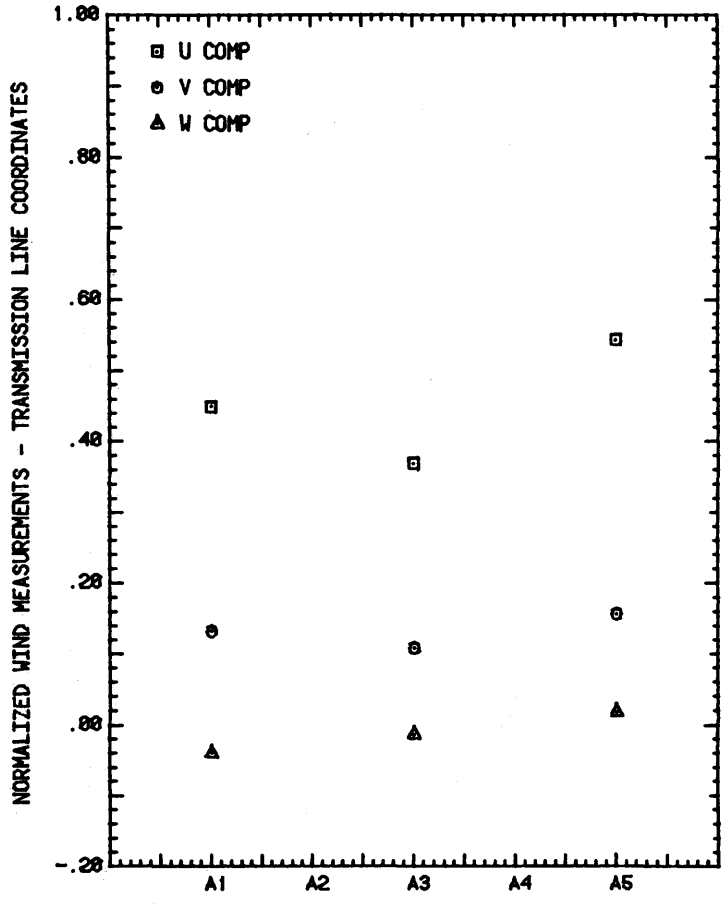


Figure F-61. Transmission line height mean speeds for Span A for the north northeast (NNE) wind direction.

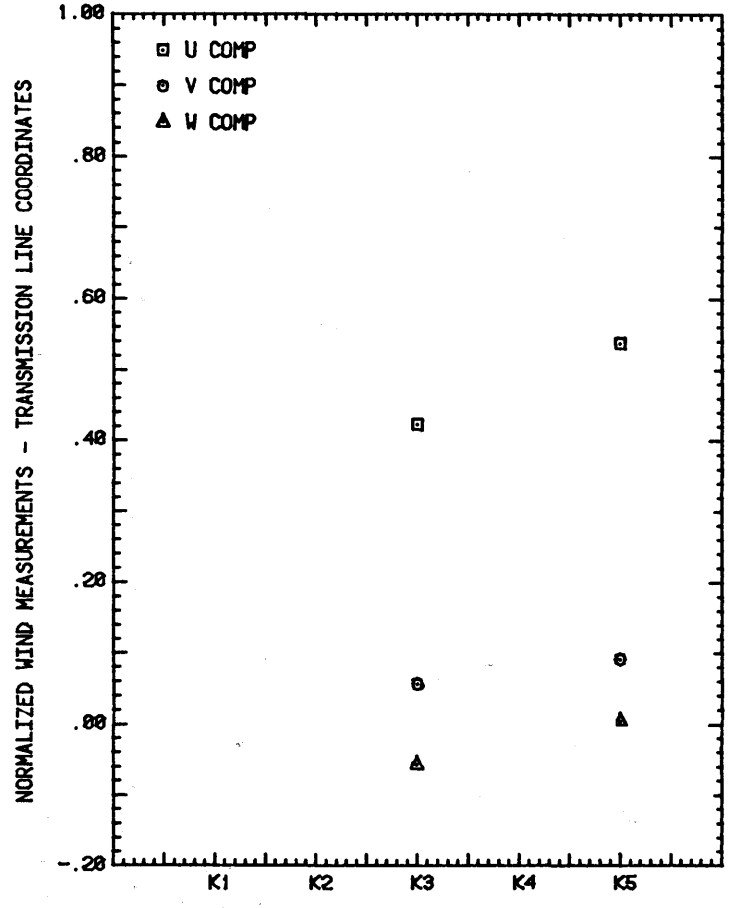


Figure F-62. Transmission line height mean speeds for Span K for the north northeast (NNE) wind direction.

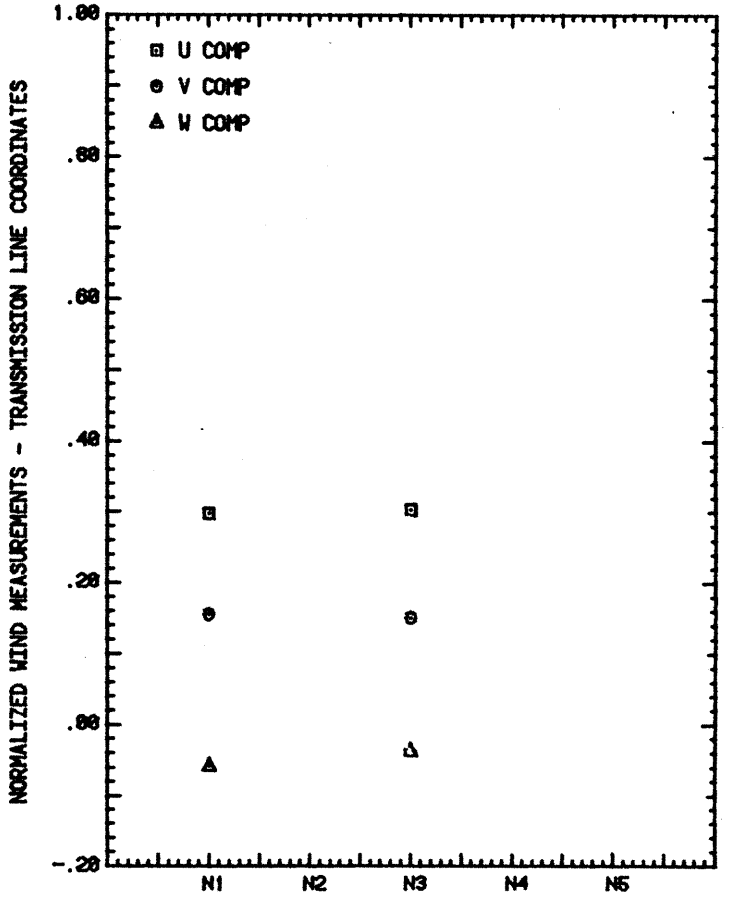


Figure F-63. Transmission line height mean speeds for Span N for the north northeast (NNE) wind direction.

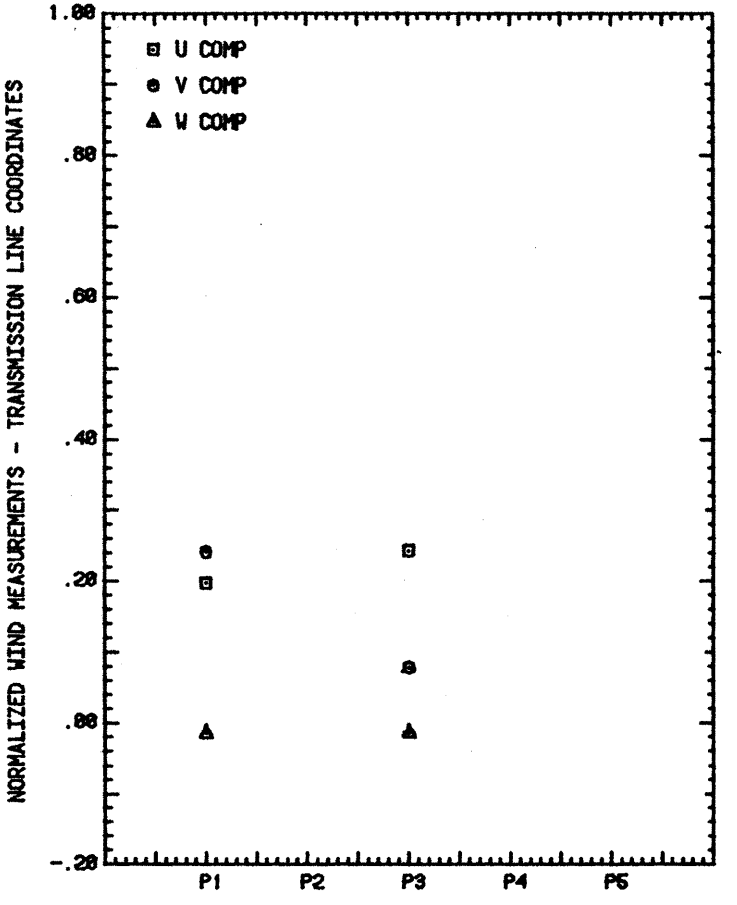


Figure F-64. Transmission line height mean speeds for Span P for the north northeast (NNE) wind direction.

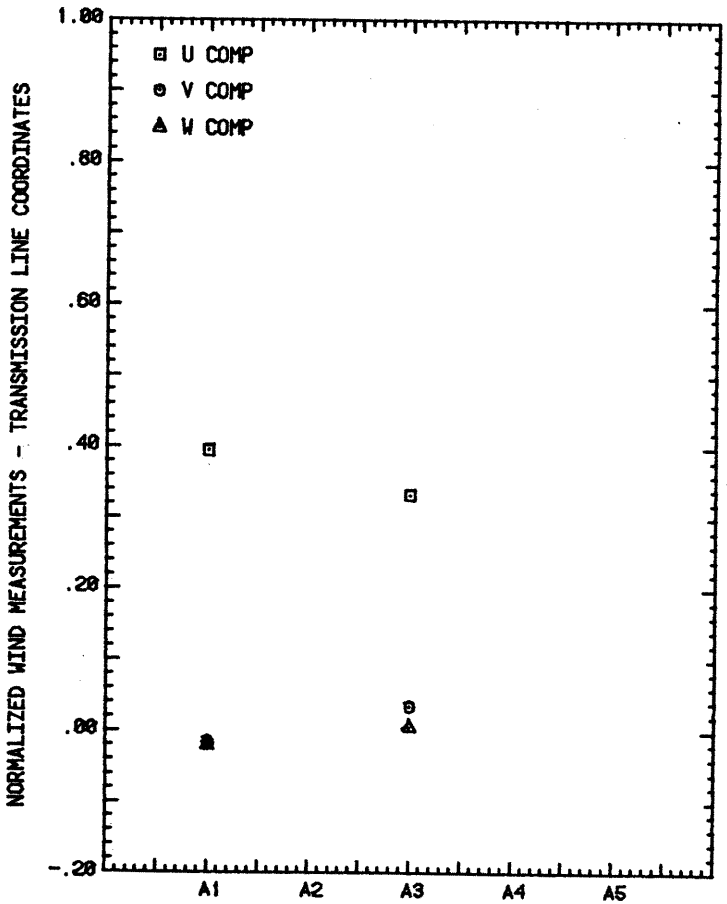


Figure F-65. Transmission line height mean speeds for Span A for the east northeast (ENE) wind direction.

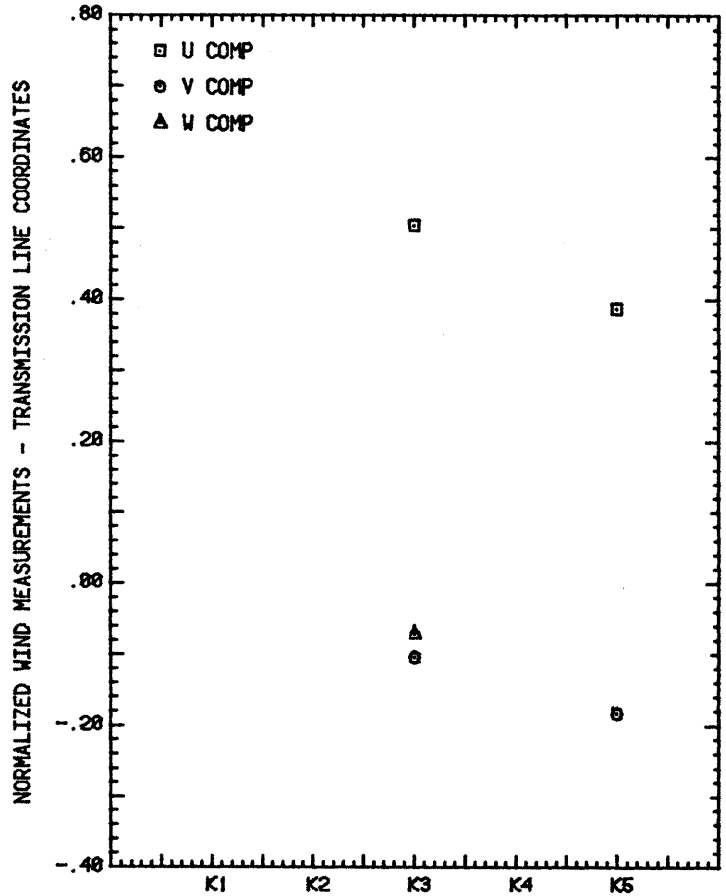


Figure F-66. Transmission line height mean speeds for Span K for the east northeast (ENE) wind direction.

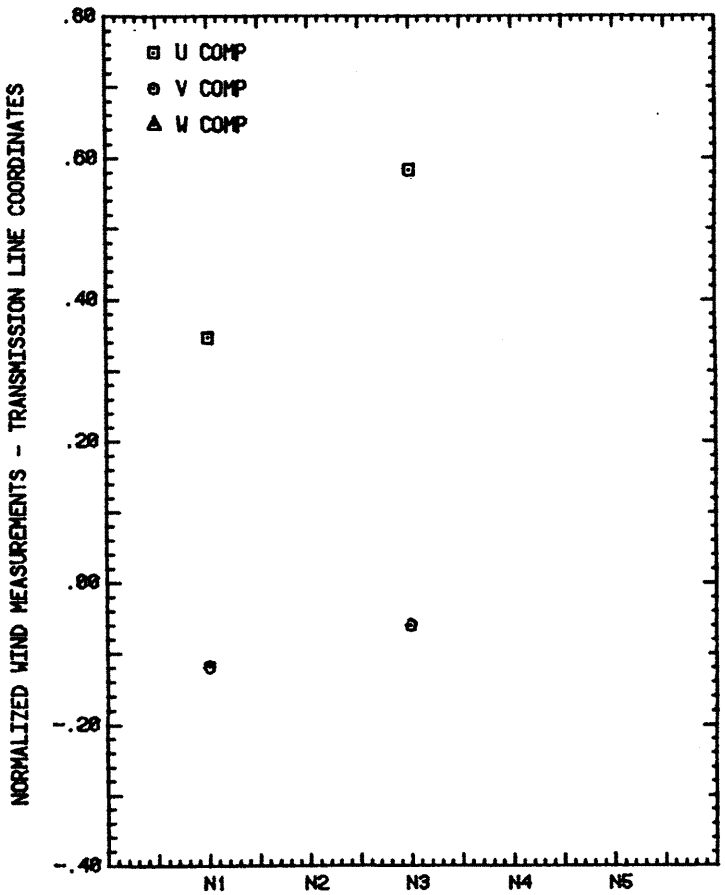


Figure F-67. Transmission line height mean speeds for Span N for the east northeast (ENE) wind direction.

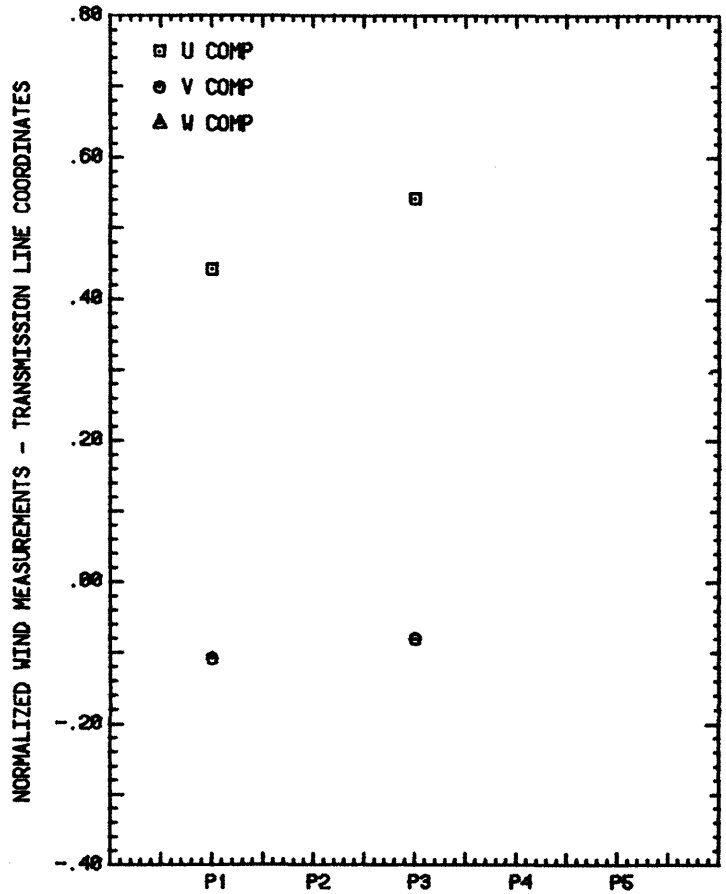


Figure F-68. Transmission line height mean speeds for Span P for the east northeast (ENE) wind direction.

APPENDIX G

DATA FOR SIX WIND DIRECTIONS

(See Table 2.2 and Fig. 1.1)

South G-2
South southwest G-10
Southwest G-16
West southwest G-21
North northeast G-27
East northeast G-30

The span data are presented in eight columns which give (all velocities and turbulence values are normalized by $\bar{U}_{ref}$): the data location code name; height above prototype ground level; mean horizontal speed perpendicular to the span; mean horizontal speed parallel to the span; vertical mean speed; horizontal turbulence intensity perpendicular to the span; horizontal turbulence intensity parallel to the span; and vertical turbulence intensity, respectively.

The anemometer data is presented as stated above except columns three and four list the azimuth (AZIMUTH-North = 0° and 360°) and total horizontal speed (SPEED), respectively, in place of U MEAN and V MEAN.

SOUTH WIND DIRECTION

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
A5110	34.1	.3390	.4163	-.0326	.07495	.09060	.05539
A5111	93.2	.4195	.4072	-.0230	.07966	.09225	.05917
A5112	137.8	.4307	.4955	-.0189	.06830		.05424
A5113	190.3	.4799	.5520	-.0116	.06851		.05949
A5120	131.2	.4834	.0846	-.0431	.12483	.08474	.07450
A5121	316.0	.5713	.1555	-.0401	.08726	.06153	.04239
A5130	170.6	.4138	.1106	.0538	.09316	.08405	.05722
A5131	318.0	.5327	.0934	-.0221	.09417	.05465	.05031
A5140	131.2	.3950	.0791	-.0898	.11138	.06183	.06698
A5141	288.0	.4138	.1127	.0417	.08260	.06713	.07035
A5150	26.2	.4060	.3921	-.0513	.10975	.10920	.04601
A5151	57.1	.4591	.4529	-.0400	.10111	.10446	.05449
A5152	113.5	.4846	.4877	-.0392	.09490	.09923	.05349
B5160	26.2	.6340	.3947	.0320	.10137		.04811
B5161	39.4	.5376	.3808		.09713	.09492	
B5162	60.4	.6313	.3929	.0019	.09167		.05023
B5163	107.6	.6450	.3209	-.0202	.07692	.07640	.04857
B5164	160.1	.6793	.4228	-.0250	.07863		.04504
B5170	304.5	.5350	.0758	-.0374	.10544	.05688	.04591
B5180	341.2	.4908	.2137	-.0714	.11119	.07603	.07693
B5190	196.9	.5465	.0389	.0719	.09950	.07242	.08300
B5200	26.2	.7343	.4571	-.0507	.11866		.04179
B5201	52.5	.6479	.2054	-.0685	.10820	.09116	.07573
B5202	105.0	.6167	.2795	-.0769	.10967	.09196	.06706
B5203	165.4	.6394	.3980	-.0722	.10220		.05975
C5210	26.2	.4497	.4419	-.0577	.10777		.05835
C5211	37.4	.4021	.5002	-.0442	.10087	.14801	.06340
C5212	93.2	.4194	.4296	-.0277	.10159	.11178	.07699
C5213	135.2	.4311	.4237	-.0113	.09905		.08273
C5220	397.6	.3197	-.1066	.0245	.14323	.09632	.05388
C5230	345.1	.3167	-.1065	-.0202	.12494	.09019	.06850
C5240	228.3	.2261	.2242	-.0615	.08368	.09057	.05291
C5250	30.8	.3869	.1639	-.0014	.11937	.08603	.05987
C5251	45.9	.4103	.4032	.0001	.10805		.06821
C5252	93.2	.4642	.2390	.0015	.11121	.07839	.06654
C5253	135.2	.4616	.4536	.0016	.08967		.06615
F5260	29.5	-.0544	-.6930	.1014	.06597	.16160	.05746
F5261	80.1	-.0056	-.6338	.0619	.06558	.11615	.06694
F5262	139.1	.0511	-.5888	.0344	.05105	.11837	.08115
F5263	174.5	.1039	-.6146	.0194	.02436		.07694
F5270	354.3	-.0862	-.2608	-.0022	.05327	.10044	.05328

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
F5280	359.6	-.2233	-.3295	.0412	.07847	.10952	.07333
F5290	236.2	-.2132	-.2791	.0955	.05855	.09774	.06728
F5300	35.4	.0919	-.5434	.0766	.01799		.04190
F5301	45.9	.0555	-.6229		.04921	.09124	
F5302	98.4	.0722	-.6567	.0535	.03294	.09391	.03719
F5304	135.2	.1186	-.7011	.0417	.01544		.04352
G5310	26.2	.3817	.7993	.0001	.13890	.19572	.05347
G5311	37.4	.3776	.8606	.0075	.12956	.19208	.05775
G5312	85.3	.4146	.8199	.0144	.11990	.18929	.06849
G5313	135.2	.4166	.9074	.0137	.11960	.18651	.07736
G5320	32.8	.2614	.3205	-.0575	.08652		.07141
G5321	65.6	.2624	.3218	-.0372	.07966		.06760
G5322	95.8	.2814	.3450	-.0247	.08565		.06762
G5323	118.1	.2532	.3105	-.0291	.08125		.06691
G5324	164.0	.3144	.3855	-.0055	.09201		.06743
G5325	168.0	.3244	.2940	-.0160	.10040	.10876	.06789
G5326	217.8	.3198	.3921	-.0062	.09067		.06931
G5327	267.7	.3569	.4376	.0008	.09353		.07066
G5330	354.3	.4443	.1955	-.0208	.12643	.10071	.07782
G5340	451.4	.4839	.2188	-.0432	.13590	.09242	.09623
G5350	26.2	.2901	.4591	-.0081	.12112	.14146	.06694
G5351	35.4	.3229	.5396	-.0066	.11441	.15107	.06814
G5352	85.3	.3023	.5557	-.0048	.10532	.14384	.08537
G5353	135.2	.3857	.5120	-.0133	.11326	.12990	.08961
H5360	26.2	.3746	.3491	.1049	.10203	.13157	.05352
H5361	35.4	.3805	.3497	.1047	.10174	.12363	.05290
H5362	87.9	.4064	.3740	.0971	.09644	.11358	.06108
H5363	137.1	.4195	.3775	.0827	.09742	.10516	.06982
H5370	254.6	.4197	.1429	.0086	.12029	.09875	.08008
H5380	590.6	.3933	.1844	-.0185	.13537	.08969	.08278
H5390	328.1	.3864	.1415	-.0184	.12846	.09285	.07929
H5400	26.2	.2629	.2283	-.0430	.12469	.10095	.05765
H5401	35.4	.2826	.2693	-.0440	.12290	.10999	.06230
H5402	85.3	.3070	.3032	-.0525	.12374	.10943	.07451
H5403	137.1	.3232	.3164	-.0628	.12599	.10684	.08210
I5410	26.2	.4532	-.0672	.0046	.14462	.09620	.04343
I5411	49.9	.4490	-.0841	-.0025	.12752	.09577	.04630
I5412	100.4	.4469	.1359	-.0168	.12281	.07077	.05113
I5413	152.9	.4892	.1033	-.0259	.12128	.06747	.05473
I5420	355.6	.3395	.0075	-.0565	.13637	.07964	.06242
I5430	472.4	.5426	.0289	-.0997	.18025	.08942	.10392
I5440	206.0	.2369	-.1892	.0602	.09444	.08897	.07108
I5450	26.2	.5683	.2149	-.0030	.13195	.11051	.06000
I5451	60.4	.6124	.2410	.0021	.11153	.08621	.06390
I5452	110.2	.6173	.2150	-.0032	.11041	.07679	.06736
I5453	160.1	.6012	.3211	-.0030	.10692	.07235	.06141

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
J5460	322.8	.3625	.3573	-.0155	.09984	.05890	.08891
J5470	288.7	.4444	.3099	-.0239	.13772	.10366	.09138
J5480	139.1	.2871	.1173	-.0077	.10361	.08486	.07228
J5481	190.3	.3089	.3788	-.0024	.09652		.08210
J5482	240.2	.3973	.4871	-.0181	.09144		.07873
J5483	290.0	.4242	.5201	-.0229	.07656		.07755
J5490	26.2	.4314	.3916	.0146	.09767	.12683	.05644
J5491	36.7	.4606	.4298	.0194	.10048	.12227	.06398
J5492	85.3	.4419	.4416	.0145	.09559	.10652	.07758
J5493	139.1	.4178	.4505	.0023	.09043	.10610	.07835
K5500	160.1	.3374	-.0474		.12984	.07885	
K5501	210.0	.3373	.0333		.13290	.08640	
K5502	259.8	.3575	.1074	-.0328	.14601	.09221	.07776
K5503	309.7	.3349	.2169		.14744	.10454	
K5504	359.6	.3524	.3225		.15090	.12909	
K5510	309.7	.2751	-.0872		.09719	.05608	
K5511	359.6	.2674	-.0641		.09841	.05825	
K5512	409.4	.2921	-.0293	.0345	.10936	.05811	.06216
K5513	459.3	.2862	.0468		.10345	.06454	
K5514	509.2	.2848	.1706		.12058	.07910	
K5520	137.8	.1447	-.0872		.07764	.03708	
K5521	187.7	.1751	-.0920		.08230	.05149	
K5522	237.5	.2474	-.0812	.0311	.10926	.07477	.06074
K5523	287.4	.3018	.0712		.13223	.07248	
K5524	337.3	.3556	.2237		.14440	.10156	
K5530	26.2	.4931	.4499	.0225	.10198	.11122	.05392
K5531	45.9	.5052	.4608	.0218	.08854	.09799	.05001
K5532	89.9	.5074	.4515	.0201	.08569	.08684	.06247
K5533	137.8	.5032	.4251	.0124	.08101	.07943	.06158
L5540	95.8	.2849	-.0742		.12446	.07319	
L5541	145.7	.3203	-.0116		.11497	.09055	
L5542	195.5	.3536	.0828	.0440	.12195	.10303	.06369
L5543	245.4	.3781	.1761	.0328	.12799	.09807	.06574
L5544	295.3	.4196	.2631	.0282	.12857	.09549	.06737
L5545	345.1	.4351	.3561	.0254	.10597		.06816
L5550	393.7	.4688	-.0945	.0533	.14150	.09895	.10233
L5551	443.6	.4694	-.0602	.0504	.14523	.09586	.09496
L5552	493.4	.4844	.0291	.0487	.14950	.08871	.09050
L5553	543.3	.5017	.1198	.0234	.15437	.09265	.08117
L5554	593.2	.5145	.2136	.0012	.15169	.09794	.06765
L5556	660.1	.7128	-.2275	.0025	.17295		.05789
L5560	156.2	.2948	.2097	-.0628	.08113	.07462	.05644
L5561	206.0	.2976	-.1344	-.0093	.09277	.06888	.05026
L5562	255.9	.3116	-.0219	-.0011	.10159	.08201	.05973
L5563	305.8	.3405	.1589	.0100	.12963	.08587	.07414
L5564	355.6	.3771	.2499	.0178	.15076	.09571	.07468
L5566	586.6	.5792	.4741	.0383	.08623		.06546
L5570	26.2	.4244	.2870	-.0350	.12323	.10114	.07190
L5571	35.4	.5167	.3294	-.0275	.11383	.10985	.06140
L5572	89.2	.5844	.3767	-.0146	.09062	.10000	.07093
L5573	135.2	.5895	.4020	-.0128	.09137	.09574	.07282
M5580	74.8	.4511	-.2187		.18210	.09441	
M5581	124.7	.4092	-.1382		.14106	.10564	
M5582	174.5	.4626	-.0153	-.0436	.15187	.10958	.06870
M5583	224.4	.4367	.1337		.14513	.08936	
M5584	274.3	.4691	.2415		.15432	.09300	

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
M5590	278.2	.3179	-.0688		.12858	.09146	
M5591	328.1	.3137	-.0346		.12143	.09121	
M5592	378.0	.3379	.0758	-.0156	.13457	.08582	.06629
M5593	427.8	.3364	.1406		.13395	.08909	
M5594	477.7	.3459	.1738		.13628	.08451	
M5600	65.6	.2975	-.1509		.10791	.05104	
M5601	119.4	.2664	-.1426	.0779	.08683	.05313	.05876
M5602	169.3	.3133	-.1341		.10496	.05733	
M5603	219.2	.3487	-.0828		.10543	.05887	
M5610	26.2	.4982	.2725	.0090	.09085	.07278	.04784
M5611	48.6	.5230	.2837	.0062	.09860	.06728	.05000
M5612	94.5	.5649	.2844	.0051	.10646	.06351	.04421
M5613	144.4	.5887	.2841	-.0008	.10033	.06000	.04303
N5620	26.2	.3473	.4405	.0207	.10685	.16170	.04874
N5621	35.4	.4294	.4533		.12184	.17713	
N5622	82.0	.3630	.4535	.0171	.10412	.16090	.04868
N5623	105.0	.3243	.5419	.0392	.08970		.04525
N5624	133.2	.3686	.4560	.0587	.10685	.14149	.05656
N5625	1364.8	.3325	.5555	.0540	.07807		.07812
N5630	236.2	.4091	.0790	-.0270	.16100	.09416	.08200
N5631	286.1	.3956	.1080	-.0244	.15306	.10306	.08015
N5632	336.0	.3967	.1427	-.0237	.14933	.11056	.07878
N5633	385.8	.4098	.1847	-.0241	.15491	.11600	.07545
N5634	435.7	.4034	.2365	-.0260	.16324	.11474	.07210
N5640	485.6	.4322	.0635		.12688	.10136	
N5641	535.4	.4179	.0817		.12228	.10121	
N5642	585.3	.4063	.0985		.12004	.09903	
N5643	635.2	.4169	.1662		.12867	.11104	
N5644	1997.4	.4158	.2275		.13469	.11386	
N5650	123.4	.3730	-.0600	-.0030	.11563	.06735	.06617
N5651	173.2	.4087	-.0534	.0241	.12725	.07653	.08572
N5652	223.1	.4398	-.0251	.0573	.14053	.08389	.10451
N5653	273.0	.4742	.0743	.0892	.15732	.09487	.10833
N5654	322.8	.3833	.2045	.0801	.13543	.10202	.07510
N5656	446.2	.3091	.5144	.1745	.07679		.09546
N5657	708.7	.4134	.6881	.0865	.17061		.05626
N5660	26.2	.3970	.2856	.0724	.14506	.16062	.07146
N5661	35.4	.4738	.5856		.12998	.13644	
N5662	78.7	.4098	.6848	.0739	.05916		.06844
N5663	95.1	.3849	.6673	.0602	.07272	.09964	.06654
N5664	146.3	.4026	.6684	.0424	.07171	.09342	.06130
05670	26.2	.5126	.4824	.0755	.07747	.09973	.03064
05671	53.8	.5265	.5051	.0683	.07132	.08449	.03593
05672	100.4	.5849	.4545	.0595	.06854	.06597	.04098
05673	150.3	.5791	.4606	.0446	.06250	.06544	.04113
05680	237.5	.5884	.1720	.0326	.10876	.08572	.06189
05681	287.4	.5964	.1947	.0434	.10906	.08119	.06445
05682	337.3	.6058	.2284	.0452	.11106	.07483	.05974
05683	387.1	.6068	.2749	.0481	.10532	.08348	.05522
05684	437.0	.6389	.3049	.0532	.11017	.07873	.05482
05690	427.2	.5459	.0635	.0777	.14592	.11736	.09688
05691	477.0	.5441	.0985	.0806	.15042	.11382	.09113
05692	534.1	.5625	.1427	.0789	.16324	.10647	.08650
05693	584.0	.5882	.2223	.0743	.17385	.09230	.08541
05694	633.9	.6236	.2641	.0809	.17489	.09311	.07665

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
05700	157.5	.5182	-.0100	-.0862	.11006	.07526	.09275
05701	207.3	.5163	.0284	-.0756	.11539	.08847	.09952
05702	257.2	.4583	.0756	-.0382	.11059	.09550	.07771
05703	307.1	.4478	.1202	-.0277	.11011	.10777	.08622
05704	357.0	.4472	.1711	-.0225	.11141	.11996	.09382
05710	26.2	.3822	.2811	-.0091	.09786	.08371	.05642
05711	55.1	.4205	.3049	-.0079	.10054	.08819	.06326
05712	114.8	.5106	.3793	-.0021	.11551	.09324	.06203
05713	154.9	.5574	.4199	.0082	.11215	.09040	.05970
P5720	26.2	.5571	.5267	.0420	.08248	.11625	.03592
P5721	57.7	.5404	.5641	.0362	.06960	.09074	.04668
P5722	99.7	.5426	.5888	.0085	.06745	.08901	.05482
P5723	150.9	.5380	.5856	.0005	.06752	.08550	.05265
P5730	370.1	.3836	.0362	.0551	.13387	.08472	.06380
P5731	419.9	.3913	.0882	.0406	.14086	.08136	.06425
P5732	469.8	.4083	.1407	.0306	.15249	.08329	.06102
P5733	519.7	.4320	.2005	.0212	.16076	.08401	.05791
P5734	569.6	.4521	.2526	.0117	.16690	.08789	.05729
P5736	769.0	.7415	-.1698	-.0076	.20597		.04519
P5740	381.2	.3845	-.0606	-.0030	.12561	.09235	.08443
P5741	431.1	.4246	.0270	.0076	.14037	.08510	.08976
P5742	481.0	.4584	.0907	.0114	.15390	.08371	.09018
P5743	530.8	.3883	.1414	.0560	.12546	.08599	.06586
P5744	580.7	.3990	.2197	.0615	.12947	.10172	.07443
P5745	631.2	.3185	.3427	.0662	.10799		.08116
P5750	255.9	.1645	.1762	.0375	.07837	.07181	.05516
P5751	305.8	.1741	.1748	.0364	.08198	.08531	.06126
P5752	355.6	.1992	.2005	.0422	.09424	.10281	.07066
P5753	405.5	.2361	.2412	.0495	.10467	.11722	.08056
P5754	455.4	.2873	.2898	.0619	.11108	.12499	.09083
P5760	26.2	.3215	.3144	.0103	.07890	.10008	.04594
P5761	40.7	.4075	.1909		.11951	.06383	
P5762	52.5	.5150	.4789	.0224	.08344	.06911	.03994
P5763	107.6	.5152	.5046	.0167	.07810	.07497	.04950
P5764	119.4	.5317	.4963		.08043	.06831	
P5765	149.6	.5232	.5017	.0162	.07645	.07213	.05182
Q5770	26.2	.8151	-.4362	.1105	.14642	.13208	.05525
Q5771	35.4	.7827	-.4096	.0934	.13603	.12047	.06093
Q5772	85.3	.7630	-.3655	.0551	.11856	.10560	.07525
Q5773	135.2	.7398	-.3523	.0306	.11347	.10240	.07795
Q5780	58.4	.3477	-.3770	-.0648	.12637	.12438	.05780
Q5781	78.7	.4816	-.2615	-.0651	.16245		.06089
Q5783	108.3	.4790	-.5485	-.0550	.13994	.10351	.06103
Q5784	158.1	.4357	-.3972	-.0479	.12727	.09864	.06339
Q5785	213.9	.3847	-.3995		.10940	.10159	
Q5786	263.8	.4576	-.4044		.11475	.09634	
Q5790	82.7	.1694	-.4949	.0398	.07227	.16885	.06967
Q5791	132.5	.1775	-.4829	.0403	.06944	.14550	.07373
Q5792	182.4	.1932	-.4734	.0378	.07277	.13103	.07716
Q5793	232.3	.2068	-.4554	.0379	.07101	.12292	.08169
Q5794	282.2	.2386	-.4554	.0372	.07565	.12319	.07654
Q5795	629.9	.2665	-.7526	.0369	.05449		.05367
Q5800	110.2	.0929	-.5234	.0380	.07091	.16729	.06683
Q5801	160.1	.1050	-.5136	.0439	.06777	.15114	.07294
Q5802	210.0	.1172	-.5251	.0500	.06874	.14503	.07830
Q5803	259.8	.1213	-.4952	.0522	.06649	.12802	.08006
Q5804	309.7	.1470	-.4847	.0623	.06826	.13153	.08084
Q5805	826.8	.5749	-.3122	.0647	.11488		.07637

SOUTH WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
Q5810	26.2	.0281	-.4849	-.0211	.07613	.14879	.05260
Q5811	35.4	.1868	-.5274	-.0240	.05812		.05558
Q5812	85.3	.0451	-.4612	-.0171	.07039	.12745	.06830
Q5813	135.2	.0712	-.4830	-.0074	.07081	.13754	.07624
Q5814	185.0	.0006	-.4469		.08671	.12990	

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9010	39.4	184.	.5661		.07602	.03287	
A9011	55.1	184.	.5729		.07545	.03214	
A9012	156.2	184.	.6643		.07321	.03934	
A9013	284.8	184.	.7222		.06890	.04681	
A9014	479.0	184.	.7854		.06557	.05644	
A9015	728.3	184.	.8515		.06131	.05865	
A9016	1123.4	184.	.9374		.04686	.04805	
A9017	1518.4	184.	.9902		.02458	.02540	
A9018	1913.4	184.	1.0031		.01478	.00821	
A9019	2586.6	184.	.9972		.01978	.00529	
A9110	26.2	172.	.4880	-.0141	.07540	.03931	.03120
A9111	68.9	178.	.5953	-.0177	.07691	.04168	.02963
A9112	106.3	180.	.6452	-.0213	.07871		.03173
A9113	167.3	178.	.6671	-.0241	.07683	.03912	.03309
A9114	250.0	178.	.7260	-.0282	.07556	.04207	.03454
A9115	373.4	178.	.7667	-.0340	.07420	.04056	.03523
A9116	911.4	178.	.8775	-.0414	.06375	.03715	.03187
A9117	1296.6	178.	.9378	-.0457	.04765	.02655	.02478
A9118	1635.2	178.	.9805	-.0495	.03297	.01616	.01733
A9119	1960.6	178.	1.0005	-.0509	.01385	.00806	.01069
A9210	26.2	172.	.3780	.0371	.08473	.06251	.07043
A9211	49.2	178.	.6721	.0293	.12369	.08368	.05179
A9212	114.2	182.	.6966	.0291	.09799	.07570	.06266
A9213	160.8	182.	.6996	.0128	.10233	.07505	.06248
A9214	238.8	180.	.7248	.0014	.10623	.06926	.05950
A9215	376.0	179.	.7579	-.0090	.10279	.05997	.05410
A9216	908.1	179.	.8785	-.0150	.08699	.04328	.04043
A9217	1289.4	179.	.9392	-.0150	.06633	.03938	.03463
A9218	1631.2	179.	.9954	-.0153	.05260	.03028	.02694
A9219	1956.7	179.	.9955	-.0146	.05606	.03026	.02559
A9370	26.2	170.	.6444	.0219	.13694	.09616	.06048
A9371	61.0	181.	.7235	.0219	.12374	.11773	.06330
A9372	119.4	183.	.7156	.0115	.10691	.09959	.06620
A9373	172.6	182.	.7063	.0048	.11447	.09059	.06928
A9374	246.7	181.	.7112	-.0117	.11674	.08151	.07129
A9375	378.0	170.	.7677	-.0266	.10954	.07029	.06224
A9376	904.9	179.	.8855	-.0441	.07334	.04141	.03356
A9377	1292.0	170.	.9735	-.0470	.05463	.02882	.02557
A9378	1646.3	179.	1.0000	-.0476	.03438	.01852	.01833
A9379	1952.8	179.	.9778		.03289	.01406	

SOUTH WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9840	26.2	183.	.7096	.0673	.10834	.06998	.04460
A9841	61.0	181.	.7121	.0514	.10376	.06513	.04241
A9842	122.0	179.	.7604	.0243	.09952	.06825	.05238
A9843	161.4	178.	.7579	.0122	.10927	.06923	.05029
A9844	238.8	178.	.7836	-.0015	.09570	.06462	.05048
A9845	373.4	175.	.8260	-.0137	.08915	.05583	.04599
A9846	910.1	173.	.8671	-.0283	.09170	.09170	.03499
A9847	1303.8	172.	.9479	-.0309	.05906	.02684	.02998
A9848	1629.9	172.	.9606	-.0362	.05730	.02793	.02702
A9849	1960.6	171.	1.0115	-.0381	.04188	.02770	.02272
A9860	26.2	186.	.5868	-.0513	.14202	.07951	.04601
A9861	57.1	187.	.6572	-.0400	.13485	.07675	.05449
A9862	113.5	187.	.6963	-.0392	.12465	.07469	.05349
A9863	174.5	185.	.7407	-.0396	.11873	.07102	.05214
A9864	243.4	184.	.7760	-.0418	.11813	.06563	.05474
A9865	383.2	183.	.8355	-.0379	.11341	.05990	.04824
A9866	914.7	181.	.9294	-.0499	.09289	.04674	.03797
A9867	1290.7	180.	.9252	-.0410	.08196	.04517	.03770
A9868	1624.7	180.	.9576	-.0311	.07899	.04380	.03699
A9869	1953.4	180.	1.0001	-.0425	.08504	.04081	.03427

SOUTH SOUTHWEST WIND DIRECTION

SOUTH SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
A6110	26.2	.1568	.1949		.03724	.06222	
A6111	35.4	.4024	.2359	.0020	.09791	.07130	.04912
A6112	85.3	.5383	.2640	.0205	.10797	.07395	.05059
A6113	135.2	.6220	.2816	.0315	.09417	.06966	.04862
A6114	185.0	.6598	.2885	.0307	.09039	.06613	.04671
A6120	215.2	.6625	.1835	.0130	.08909	.05916	.04424
A6121	265.1	.6926	.2105	.0113	.08507	.06014	.04117
A6122	315.0	.7020	.2179	.0090	.08341	.05748	.03965
A6123	364.8	.7155	.2357	.0061	.08129	.05679	.03858
A6124	414.7	.7309	.2388	.0047	.08414	.05803	.03829
A6125	131.2	.6038	.1660	.0102	.10168	.06605	.05203
A6126	165.4	.6277	.1751	.0104	.09315	.06275	.04700
A6130	170.6	.6525	.1389	.0065	.08731	.05905	.04807
A6131	220.5	.6959	.1430	-.0025	.08984	.06287	.05676
A6132	267.7	.6909	.1159	-.0121	.09228	.05529	.05769
A6133	317.6	.6977	.1255	-.0191	.08937	.05460	.05470
A6134	367.5	.6963	.1388	-.0273	.09589	.05494	.05318
A6135	417.3	.7019	.1691	-.0367	.09500	.05747	.05441
A6140	131.2	.5663	-.1577	.0155	.09739	.07257	.05028
A6141	187.7	.5657	-.1467	.0317	.09189	.07372	.06077
A6142	237.5	.5461	-.1377	.0499	.09081	.07182	.06587
A6143	287.4	.5209	-.1183	.0548	.09381	.06925	.07442
A6144	337.3	.4821	-.0834	.0606	.09592	.06849	.07232
A6145	387.1	.4809	-.0295	.0706	.10141	.07756	.07553
A6150	35.4	.6768	.1599	-.0384	.11193	.07602	.05259
A6151	78.7	.7041	.1995	-.0338	.10902	.07546	.07295
A6152	131.2	.7358	.2357	-.0422	.11038	.07118	.07058
B6160	35.4	.2431	.4161	-.0285	.06680		.04155
B6161	60.4	.3958	.0420	-.0395	.09905	.09186	.04301
B6162	110.2	.5922	.0240	-.0200	.12155	.08340	.04157
B6163	160.1	.7471	.0343		.10836	.06160	
B6170	304.5	.7564	-.0152	-.0266	.09369	.05588	.04288
B6180	175.2	.7428	-.0196	-.0590	.09969	.06259	.04205
B6181	350.4	.7025	-.2641	-.0647	.09613		.04549
B6190	254.6	.7218	-.0048	-.0405	.10991	.05745	.06013
B6200	35.4	.7748	.3481	-.0429	.10913	.07701	.05061
B6201	65.6	.8542	.2544	-.0126	.09726	.07194	.04868
B6202	115.5	.8357	.1713	-.0081	.09143	.06161	.04038
B6203	165.4	.9451	.1466		.09504	.05842	
C6210	35.4	.3421	.3483	.0524	.11199	.11462	.06118
C6211	85.3	.5755	.2503	.0574	.12048	.09148	.05755
C6212	135.2	.6401	.2396		.09923	.07935	
C6220	397.6	.7675	.1110	-.0152	.08249	.07981	.04007
C6230	345.1	.5959	-.2771	-.0003	.13731	.08657	.07020
C6240	228.3	.4711	-.5630	-.0393	.13316	.12722	.12564
C6250	35.4	.5732	.1280	.0364	.11342	.08850	.05027
C6251	85.3	.6003	.1723	.0398	.11145	.08212	.05864
C6252	135.2	.6248	.2213	.0351	.11145	.07614	.05383

SOUTH SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
F6260	35.4	-.2349	-.8754		.10306	.11943	
F6261	85.3	.0072	-.9012	.0979	.06243	.11445	.05537
F6262	135.2	.0056	-.8835	.0785	.05710	.10630	.04316
F6263	185.0	-.2342	-.8723		.07042	.10296	
F6270	353.0	-.2887	-.5840	.0781	.06042	.09487	.04473
F6280	359.6	-.1853	-.5545	-.0679	.03919	.10263	.05589
F6290	232.3	-.2095	-.4509	.0335	.05289	.08700	.06480
F6300	35.4	.0547	-.5375		.06544	.08346	
F6301	74.8	.0375	-.6313	.0358	.04012	.10501	.04658
F6302	124.7	.0159	-.7207	.0288	.04042	.10609	.03937
F6303	174.5	-.1351	-.7521		.05831	.09913	
G6310	35.4	.3498	.3681	.0370	.08659	.08371	.06679
G6311	85.3	.4772	.4172	.0262	.09854	.09364	.05856
G6312	135.2	.6051	.4028	.0229	.09324	.07999	.04911
G6320	168.0	.5520	.3186	-.0351	.13377	.11047	.09376
G6330	354.3	.7048	.1826	-.0566	.11185	.08509	.07263
G6340	451.4	.5390	.1398	.0208	.09367	.07858	.08206
G6350	35.4	.6077	.4747	.0094	.11577	.10127	.05335
G6351	85.3	.6213	.4454	-.0000	.09412	.09257	.05822
G6352	135.2	.6856	.4197	-.0139	.09771	.08985	.05937
H6360	35.4	.5259	.1532	.1156	.11570	.08714	.05209
H6361	85.3	.5546	.1879	.1098	.09916	.07612	.05551
H6362	135.2	.5766	.2205	.1029	.09997	.06976	.05834
H6370	254.6	.6402	.1198	.0022	.09529	.07685	.05532
H6380	590.6	.6501	.1742	-.0543	.12168	.08634	.07261
H6390	481.6	.4975	.1818	.0116	.11439	.08425	.08521
H6400	35.4	.2384	.3167	.0111	.11089	.13492	.05749
H6401	85.3	.3777	.3048	.0178	.13406	.11530	.07011
H6402	135.2	.4246	.2774	.0162	.12921	.10354	.07625
I6410	35.4	.5490	-.2441	-.0174	.15009	.11659	.05866
I6411	85.3	.5351	-.2634	-.0175	.12327	.13116	.07284
I6420	357.0	.6905	-.0966	-.1573	.14494	.09740	.09334
I6430	472.4	.5004	-.0591	.0753	.11585	.08830	.07893
I6440	206.0	.3868	-.3237	.0603	.11213	.11928	.10727
I6450	60.4	.6473	.1176	.0517	.13845	.07706	.05429
I6451	110.2	.7000	.0917	.0680	.11336	.06950	.05810
J6460	322.8	.6089	.2476	-.0101	.09954	.07028	.06245
J6470	290.0	.4528	.1397	.0817	.09435	.07098	.07608
J6480	140.4	.4316	.1069	.1152	.09468	.05688	.07059
J6490	35.4	.4911	.2666	.0713	.11283	.10237	.04840
J6491	85.3	.5235	.2689	.0704	.10816	.09898	.05918
J6492	135.2	.5577	.3140	.0704	.10637	.09905	.06242

SOUTH SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
K6500	259.8	.5272	.1118	-.0025	.11635	.08421	.08582
K6510	409.4	.5471	.1127	-.0903	.11253	.07697	.09244
K6520	237.5	.4050	.0720	.0266	.11159	.07562	.06652
K6530	35.4	.4154	.1436	-.0080	.13199	.08409	.04186
K6531	85.3	.4630	.1598	.0000	.11121	.08801	.05677
K6532	135.2	.5006	.1868	-.0011	.10429	.08969	.05841
L6540	195.5	.5750	.0363	.0163	.11110	.07150	.06377
L6550	498.7	.5053	-.0462	-.0683	.10161	.06855	.07029
L6560	255.9	.3472	.0407	.0302	.09601	.06633	.06839
L6570	35.4	.4906	.2629	-.0422	.12298	.07856	.07954
L6571	85.3	.6467	.2855	-.0098	.08744	.05934	.05689
L6572	135.2	.6907	.2725	-.0107	.09364	.05879	.06141
M6580	174.5	.7191	-.0318	-.0051	.08731	.06015	.05022
M6590	378.0	.6222	.0476	-.1601	.09957	.06666	.07487
M6600	119.4	.5899	-.3215	.2070	.09035	.07846	.06397
M6610	44.6	.5048	.1554	-.0284	.08589	.06198	.03361
M6611	94.5	.6179	.1647	.0173	.08249	.06370	.04058
N6620	35.4	.3749	.5775		.07780	.08323	
N6621	85.3	.6536	.5957		.09685	.06632	
N6622	135.2	.6038	.5698	.1189	.07628	.06004	.04379
N6630	254.6	.6923	.2326		.08898	.05913	
N6631	290.0	.7029	.2533		.08667	.06099	
N6632	339.9	.3302	.2742	.0588	.04122	.06186	.04131
N6633	389.8	.6527	.2862		.08665	.05919	
N6634	439.6	.6619	.3091		.08473	.05780	
N6640	485.6	.5993	.1178		.08711	.07272	
N6641	535.4	.5902	.1458		.09139	.06896	
N6642	585.3	.5794	.1680	-.0500	.09139	.06472	.06888
N6643	635.2	.5797	.1911		.09337	.05994	
N6644	685.0	.5800	.2179		.09954	.06040	
N6650	123.4	.3335	-.0385		.11297	.06564	
N6651	173.2	.4220	-.0093		.12033	.06469	
N6652	223.1	.4487	.0129	-.0303	.11737	.06078	.07227
N6653	273.0	.4512	.0785		.12205	.06920	
N6654	322.8	.4386	.1650		.12420	.09095	
N6660	35.4	.2396	.5680	.0387	.10159	.09103	.05478
N6661	85.3	.4974	.5906	.0779	.07382	.07110	.04698
N6662	135.2	.6108	.5871	.0616	.07857	.06926	.05321
O6670	49.9	.5399	.3235	.0317	.10305	.06976	.04505
O6671	99.7	.6327	.2793	.0469	.09698	.06783	.04355
O6672	149.6	.6661	.2840		.09242	.06468	

SOUTH SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
06680	337.3	.7095	.1844	.0450	.08129	.05071	.04897
06690	534.1	.6683	.1708	-.0370	.08637	.05242	.05090
06700	257.2	.6240	.1880	.0300	.09822	.06246	.08691
06710	35.4	.1650	.2352		.04557	.06221	
06711	55.1	.4320	.1865	.0460	.11364	.08564	.05850
06712	105.0	.4829	.1953	.0719	.11916	.08397	.06873
06713	154.9	.5925	.2622		.11544	.08030	
P6720	45.9	.4414	.4111	.0700	.08794	.08588	.04161
P6721	95.8	.5891	.4297	.0737	.08572	.07466	.04577
P6722	132.5	.6171	.3556	.0784	.07701	.07074	.05201
P6730	238.8	.4689	.4624	-.0858	.07277		.05414
P6731	370.1	.4152	.4745	-.0664	.07233	.09536	.05060
P6732	419.9	.4630	.4306	-.0604	.08081	.08987	.04803
P6733	469.8	.4578	.4331	-.0565	.08102	.08477	.04510
P6734	519.7	.4532	.4632	-.0467	.07743	.08824	.04504
P6735	556.4	.4767	.4794	-.0503	.07185	.08134	.04360
P6740	381.9	.4981	.0646	.0064	.10062	.06910	.07373
P6741	431.8	.5002	.1171	.0054	.10621	.07962	.07902
P6742	481.6	.5265	.1919	-.0296	.12775	.09296	.08819
P6743	531.5	.5639	.2247	-.0423	.12607	.09072	.08910
P6744	581.4	.5424	.1583	-.0020	.11842	.08321	.07841
P6750	255.9	.2364	-.1655	.0060	.09404	.08485	.07800
P6751	305.8	.1733	-.1070	.0002	.08100	.06995	.05255
P6752	355.6	.2037	.1320	-.0351	.10533	.07945	.05910
P6753	405.5	.2759	.1774	-.0412	.12814	.09929	.08257
P6754	455.4	.3787	.2311	-.0525	.14230	.10656	.10236
P6760	49.9	.4412	.4279	.0367	.10928	.11394	.06134
P6761	99.7	.5521	.4251	.0343	.11407	.10308	.05319
P6762	149.6	.5763	.4295	.0373	.10166	.10175	.05496
Q6770	35.4	.5407	-.5077	.0933	.09086	.10209	.04855
Q6771	85.3	.4927	-.5975	.0686	.07382	.08281	.05341
Q6772	135.2	.4823	-.5898		.07994	.07981	
Q6780	164.0	.2301	-.5241	.0415	.06167	.11009	.05293
Q6790	182.4	.1157	-.5806	-.0473	.04869	.12382	.06333
Q6800	210.0	.0055	-.5429	-.0356	.04082	.10487	.06871
Q6810	35.4	-.0261	-.5204	.0565	.04714	.10279	.04408
Q6811	85.3	-.0242	-.5560	.0775	.04087	.09140	.05025
Q6812	135.2	-.0999	-.5347		.06483	.09478	

SOUTH SOUTHWEST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9110	35.4	204.	.5669	.0224	.07902	.04417	.04215
A9111	78.7	206.	.6222	-.0574	.07119	.04267	.04044
A9112	131.2	205.	.6618	-.0664	.07408	.04029	.04053
A9113	262.5	206.	.7375	-.0728	.07479	.04110	.04236
A9114	459.3	206.	.8011	-.0805	.06875	.04043	.04185
A9115	656.2	206.	.8436	-.0455	.06398	.03897	.03863
A9116	984.3	206.	.9090	-.0493	.05881	.03460	.03577
A9117	1312.3	206.	.9685	-.0532	.04447	.02648	.02663
A9118	1968.5	207.	1.0189	-.0600	.01812	.00782	.00932
A9119	3280.8	207.	1.0162	-.0601	.01163	.00398	.00459
A9119	4593.2	207.	.9751		.01238	.00366	
A9119	6561.7	207.	.9767		.01913	.00425	
A9119	9842.5	206.	.9873		.02393	.00497	
A9119	13123.	207.	.9889		.02037	.00375	
A9119	14829.	207.	.9817		.01312	.00500	
A9210	35.4	192.	.7560	.0202	.11350	.09845	.04335
A9211	78.7	202.	.8167	.0342	.09430	.06598	.05472
A9212	131.2	202.	.7737	.0329	.09586	.05965	.05158
A9213	262.5	203.	.8026	.0301	.10228	.05279	.04792
A9214	459.3	200.	.8229	.0275	.08671	.05134	.04476
A9215	656.2	202.	.8533	.0267	.10030	.05122	.04538
A9216	984.3	201.	.8548	.0242	.09766	.04920	.04339
A9217	1312.3	200.	.8899	.0184	.08509	.04600	.04430
A9218	1968.5	201.	.9658	.0161	.08089	.04418	.04322
A9219	3280.8	200.	.9914	.0301	.07222	.04279	.03705
A9370	35.4	187.	.6193	.0207	.12166	.08355	.05431
A9371	78.7	205.	.7227	.0528	.09358	.06894	.04757
A9372	131.2	206.	.7702	.0604	.08982	.06674	.05077
A9373	262.5	209.	.7556	.0523	.08610	.05328	.04887
A9374	459.3	205.	.8037	.0473	.09955	.05042	.04274
A9375	656.2	209.	.8455	.0362	.07276	.04498	.04044
A9376	984.3	208.	.8740	.0248	.07617	.04252	.03855
A9377	1312.3	208.	.9054	.0223	.06781	.03879	.03910
A9378	1968.5	207.	1.0004	.0138	.03779	.02057	.03332
A9379	3280.8	206.	1.0128	.0097	.02784	.01165	.02014
A9840	35.4	203.	.5676	.0133	.11240		.06235
A9841	78.7	203.	.6108	.0258	.12188		.07150
A9842	131.2	203.	.6690	.0193	.13157		.06668
A9843	262.5	203.	.7678	.0161	.09451		.04640
A9844	459.3	203.	.8237	.0080	.07938		.04043
A9845	656.2	203.	.8614	.0027	.07775		.03808
A9846	984.3	203.	.9092	-.0040	.07085		.03676
A9847	1312.3	203.	.9408	-.0081	.05911		.03112
A9848	1968.5	203.	.9921	-.0149	.04319		.02456
A9849	3280.8	203.	1.0000	-.0222	.02290		.01348
A9860	35.4	215.	.7613	-.0384	.11374	.07464	.05259
A9861	78.7	213.	.7911	-.0338	.11707	.06980	.07295
A9862	131.2	213.	.8309	-.0422	.11870	.06466	.07058
A9863	262.5	209.	.8769	-.0383	.09754	.05012	.05281
A9864	459.3	208.	.9198	-.0270	.08131	.04023	.04273
A9865	656.2	206.	.9264	-.0217	.08998	.03911	.03838
A9866	984.3	207.	.9622	-.0197	.07369	.03586	.03570
A9867	1312.3	206.	.9767	-.0147	.05589	.02649	.03643
A9868	1968.5	205.	1.0025	-.0206	.04535	.01838	.03042
A9869	3280.8	204.	1.0066	-.0187	.03579	.01630	.01893

SOUTHWEST WIND DIRECTION

SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	VTURB	W TURB
A1110	85.3	.5567	.0237	.0072	.11727	.05866	.04490
A1111	139.8	.6129	.0172	.0067	.11114	.05600	.04274
A1120	315.0	.5987	.0322	-.0176	.10554	.06139	.04822
A1130	288.7	.7142	.0809	-.0157	.08569	.04773	.04507
A1131	315.0	.7132	.0812		.08186	.04933	
A1132	367.5	.6977	.0744		.08537	.05129	
A1140	288.7	.7640	-.0134	-.0604	.09124	.05070	.04661
A1150	26.2	.5667	.0487	-.0011	.11237	.08537	.04643
A1151	78.7	.6579	.0081	.0186	.11234	.08817	.06546
A1152	131.2	.6560	.0259	.0193	.11571	.08093	.06720
B1160	60.4	.4681	-.1631	-.0186	.10360	.06875	.04211
B1161	154.2	.5801	-.1655	-.0116	.10969	.06961	.04946
B1170	304.5	.5099	-.0866	.0085	.10440	.06002	.06301
B1180	350.4	.6875	-.1365	-.0501	.08988	.05408	.04912
B1190	254.6	.7071	-.1255	-.0480	.09343	.06734	.05000
B1200	65.6	.7527	-.0324	-.0081	.11778	.06565	.04695
B1201	124.7	.7750	-.0697	-.0034	.10221	.05683	.04876
C1210	35.4	.4554	.0133	.0380	.10385	.07886	.04433
C1211	116.1	.6430	-.0079	.0427	.08808	.06129	.03823
C1220	397.6	.6393	-.0796	.0089	.08762	.05011	.04261
C1230	345.1	.4942	-.1510	-.0666	.09693	.06109	.06329
C1240	228.3	.4761	-.2267	-.0931	.13790	.08234	.10106
C1250	35.4	.6436	.1121	.0771	.08551	.08327	.04175
C1251	101.0	.7045	.1094	.0495	.10544	.06366	.04672
F1260	85.3	-.4272	-.7769	.0910	.06937	.08707	.05120
F1261	150.9	-.4720	-.7317	.0589	.07008	.07717	.04354
F1270	353.0	-.4572	-.5208	.0509	.07100	.07009	.04233
F1280	359.6	-.4066	-.5450	.0047	.06081	.07786	.04501
F1290	232.3	-.3242	-.4952	-.0416	.06492	.07736	.05561
F1300	74.8	-.1503	-.4943	.0221	.06318	.10716	.05746
F1301	140.4	-.2697	-.5602	.0158	.06539	.10237	.04629
G1310	35.4	.4884	.1918	.0036	.09824	.06584	.04612
G1311	111.5	.5258	.1244	-.0085	.10243	.06619	.06054
G1320	168.0	.4774	.0802	-.0754	.14911	.08142	.07713
G1330	354.3	.7968	.0938	-.0040	.06837	.04563	.03693
G1340	451.4	.7916	.0997	-.0326	.07468	.04655	.04666
G1350	35.4	.7224	.0407	-.0509	.10100	.07855	.04294
G1351	101.0	.7348	.0754	-.0310	.09491	.06307	.05619

SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	VTURB	W TURB
H1360	35.4	.4917	.2271	.0898	.09154	.08415	.05636
H1361	97.8	.5502	.1311	.0303	.10532	.06083	.05457
H1370	254.6	.7055	-.0240	.0178	.07766	.04927	.03896
H1380	590.6	.7809	-.0023	-.0169	.07083	.04867	.03700
H1390	481.6	.7773	.0398	-.0368	.07441	.04991	.04192
H1400	35.4	.4671	-.0423	-.0197	.11528	.07220	.04640
H1401	110.2	.5716	-.0479	-.0145	.10407	.07399	.05124
I1410	35.4	.6351	-.2113	-.0049	.08269	.06196	.03460
I1411	101.0	.7137	-.3818	-.0068	.07491	.06394	.04080
I1420	357.0	.6346	-.3156	-.1895	.08893	.06235	.05168
I1430	472.4	.5984	-.1725	.0845	.08415	.07428	.08270
I1440	206.0	.3470	-.3719	.0340	.07699	.07970	.09218
I1450	60.4	.5596	-.1674	.0725	.12910	.07372	.05961
I1451	126.0	.7105	-.2046	.1061	.08365	.05855	.04528
J1460	322.8	.5962	.0590	-.0110	.08225	.05932	.05950
J1470	290.0	.5320	.0795	.1130	.08532	.05929	.05965
J1480	140.4	.4907	.0229	.1473	.07581	.05585	.04336
J1490	35.4	.7718	.0804	.1208	.09361	.06400	.04910
J1491	101.0	.8021	.0689	.0812	.09215	.05836	.04388
K1500	259.8	.5500	-.1002	-.0294	.09910	.07838	.06143
K1510	409.4	.5314	-.0821	.0709	.07296	.06267	.05905
K1520	237.5	.4977	-.1331	.0023	.09814	.06063	.07251
K1530	35.4	.5950	.0161	-.0033	.10760	.06938	.04663
K1531	72.2	.6417	.0022	.0078	.09428		.04062
K1532	106.3	.7391	-.0302		.08684	.05325	
L1540	195.5	.6199	.0288	.0037	.09426	.05742	.05280
L1550	498.7	.6008	.0230	.0232	.07318	.06093	.05393
L1560	255.9	.4812	.0315	-.0363	.09139	.04559	.06222
L1570	34.1	.4702	-.0150	-.0320	.08433	.05693	.04326
L1571	99.7	.5697	.0058	.0053	.09280	.05761	.04174
M1580	174.5	.7406	-.2043	.0345	.08599	.05887	.04320
M1590	378.0	.7532	-.1635	-.0114	.08444	.05180	.04207
M1600	119.4	.6235	-.3286	.0781	.07020	.05279	.06255
M1610	44.6	.5344	-.0348	.0261	.07158	.04948	.03631
M1611	110.2	.6130	-.0766	.0393	.09552	.05530	.04222
N1620	30.8	.5362	.2903	.0814	.09720	.08925	.06021
N1621	85.3	.6080	.2591	.0704	.10828	.07977	.06266
N1622	135.2	.6309	.2356	.0633	.11402	.07616	.05631
N1630	238.2	.6996	.1391	.0505	.08304	.05210	.04567

SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	VTURB	W TURB
N1631	288.1	.7208	.1418	.0512	.08163	.05268	.04631
N1632	337.9	.7378	.1560	.0498	.08082	.05086	.04496
N1633	387.8	.7668	.1661	.0524	.07737	.05002	.04163
N1634	437.7	.7402	.1674	.0465	.07465	.05244	.03933
N1640	485.6	.7294	.0898	-.0107	.07554	.04682	.03902
N1641	535.4	.7554	.1107	-.0139	.07564	.04582	.04158
N1642	585.3	.7462	.1147	-.0155	.07614	.04448	.04139
N1643	635.2	.7509	.1439	-.0164	.07604	.04727	.04047
N1644	685.0	.7583	.1521	-.0184	.07727	.04642	.04123
N1650	122.0	.4155	.0497	-.0671	.13278	.06636	.07962
N1651	171.9	.5393	.0505	-.0846	.13668	.07283	.07486
N1652	223.1	.5998	.0835		.11636	.06380	
N1653	273.0	.6994	.1135		.10151	.05552	
N1654	322.8	.7134	.1268		.09212	.04945	
N1660	30.8	.5890	.3614	.0281	.10725	.07269	.04893
N1661	88.6	.6829	.2956	.0235	.10362	.06021	.04721
N1662	126.0	.7336	.1843	.0151	.09592		.04880
O1670	47.2	.6567	-.0327	.0003	.09388	.04883	.03419
O1671	115.5	.7521	-.0431	.0136	.08095	.04371	.03478
O1680	337.3	.7070	-.0755	-.0035	.09708	.05092	.04100
O1690	534.1	.7841	-.0238	.0160	.08073	.04640	.03873
O1700	257.2	.7446	-.0240	.0405	.08646	.04970	.03917
O1710	55.1	.5593	-.0814	.0818	.10101	.07640	.04592
O1711	120.7	.6812	-.0643	.0709	.09213	.06074	.04112
P1720	26.2	.4340	.0929	.0348	.13807	.10676	.04345
P1721	44.6	.5492	.0343	.0424	.11041	.06980	.04466
P1722	94.5	.6967	.0557	.0642	.10030	.05956	.04008
P1723	144.4	.7307	.0451	.0662	.09309	.04964	.04157
P1730	469.8	.8012	-.0730	-.0045	.08213	.04942	.03893
P1740	381.9	.5166	-.1160	-.0487	.08144	.05018	.05249
P1741	431.8	.5440	-.0583	-.0419	.09044	.05780	.05575
P1742	481.6	.5520	-.0333	-.0401	.09623	.05448	.05109
P1743	531.5	.6050	-.0152	-.0467	.11028	.05144	.04902
P1744	581.4	.6245	.0010	-.0392	.10687	.05076	.04543
P1750	355.6	.3881	.0253	-.0706	.13274	.06236	.07519
P1760	26.2	.3819	.0881	-.0295	.11410	.06841	.05141
P1761	49.9	.4910	.1040	-.0055	.11562	.07228	.05352
P1762	85.3	.5954	.1135		.10754	.06104	
P1763	99.7	.6545	.1278	.0196	.09904	.05481	.03883
P1764	149.6	.7053	.1139	.0220	.09547	.05171	.03806
Q1770	35.4	.2292	-.6118	.1082	.05530	.09469	.03806
Q1771	101.0	.2250	-.6970	.0604	.04781	.09483	.03971
Q1780	164.0	.1353	-.6019	.0330	.03976	.08860	.04312
Q1790	182.4	.1615	-.6643	-.0104	.03374	.07984	.04048
Q1800	210.0	.1424	-.6979	-.0012	.02959	.07030	.04113
Q1810	35.4	.0922	-.6237	.0140	.02696	.06996	.03193
Q1811	101.0	.1570	-.6987	.0246	.03178	.06475	.04046

SOUTHWEST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9110	26.2	225.	.5322	.0037	.08657		.03376
A9111	78.7	225.	.6474	.0011	.08140		.03195
A9112	131.2	225.	.6839	-.0002	.08087		.03328
A9113	262.5	225.	.7324	-.0015	.07400		.03486
A9114	459.3	225.	.7912	-.0069	.06922		.03602
A9115	656.2	225.	.8397	-.0112	.06395		.03567
A9116	984.3	225.	.9000	-.0161	.05538		.03164
A9117	1312.3	225.	.9256	-.0195	.04738		.02555
A9118	1968.5	225.	1.0000	-.0251	.02098		.01243
A9210	26.2	198.	.3701	.0381	.10698	.08273	.05626
A9211	65.6	220.	.5709	.0521	.13247	.08346	.05768
A9212	131.2	224.	.6571	.0601	.14159	.08312	.06048
A9213	262.5	223.	.7269	.0624	.10309	.06167	.04969
A9214	459.3	223.	.8035	.0369	.09984	.05127	.04405
A9215	656.2	224.	.8581	.0273	.09613	.05203	.04415
A9216	984.3	226.	.9082	.0246	.08258	.04678	.04349
A9217	1312.3	224.	.9170	.0097	.07867	.04750	.03927
A9218	1968.5	224.	.9679	.0048	.06887	.04055	.03835
A9219	3280.8	223.	.9865	-.0065	.04231	.02584	.02786
A9370	26.2	215.	.5567	.0237	.10221	.07046	.04832
A9371	78.7	218.	.6610	.0513	.10262	.05650	.04040
A9372	131.2	224.	.7183	.0623	.09230	.04917	.03877
A9373	262.5	226.	.7675	.0544	.07993	.04477	.04161
A9374	459.3	225.	.8028	.0412	.07753	.04376	.04150
A9375	656.2	225.	.8499	.0281	.07476	.04194	.04071
A9376	984.3	226.	.9010	.0209	.07162	.03736	.03890
A9377	1312.3	225.	.9616	.0086	.05416	.03178	.03217
A9378	1968.5	224.	.9607	.0025	.06759	.02476	.02720
A9379	3280.8	224.	.9965	-.0033	.01496	.00598	.01049
A9840	26.2	226.	.6286	-.0034	.10689	.05916	.04857
A9841	78.7	226.	.6915	-.0041	.11013	.05850	.04272
A9842	131.2	227.	.7299	.0045	.09529	.05478	.04033
A9843	262.5	226.	.7620	.0116	.09467	.05094	.04053
A9844	459.3	226.	.7969	.0116	.08735	.04839	.04063
A9845	656.2	225.	.8302	.0107	.08836	.04715	.03900
A9846	984.3	224.	.8672	.0121	.08728	.04382	.03850
A9847	1312.3	225.	.9262	.0111	.06435	.03645	.03627
A9848	1968.5	225.	.9512	.0084	.05925		.03198
A9849	3280.8	225.	1.0000	.0064	.02145		.01706
A9860	26.2	223.	.5543	-.0011	.11217	.08446	.04643
A9861	78.7	228.	.6719	.0186	.10820	.08732	.06546
A9862	131.2	227.	.6679	.0193	.11406	.07938	.06720
A9863	262.5	226.	.7600	.0150	.11596	.06911	.05934
A9864	459.3	226.	.8321	.0124	.08947	.05140	.04591
A9865	656.2	226.	.8693	.0101	.08015	.04827	.04397
A9866	984.3	226.	.9064	.0125	.07783	.04706	.04284
A9867	1312.3	227.	.9241	.0090	.07088	.04097	.04247
A9868	1968.5	226.	.9655	.0107	.05625	.03156	.03778
A9869	3280.8	225.	1.0003	.0154	.02357	.01366	.01936

WEST SOUTHWEST WIND DIRECTION

WEST SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
A2110	30.8	.4266	-.1656	-.0484	.11868	.06419	.04426
A2111	85.3	.5305	-.2046	-.0224	.11887	.07889	.05558
A2112	135.2	.5921	-.2390	-.0271	.11481	.07884	.05336
A2113	185.0	.6839	-.2690	-.0236	.11731	.08004	.05153
A2120	131.2	.4477	-.0721	-.0390	.12830	.06034	.07945
A2121	165.4	.4800	-.1023	-.0555	.13757	.06032	.08056
A2122	215.2	.5440	-.1954	-.0633	.14100	.07579	.07603
A2123	265.1	.5881	-.2135	-.0624	.12990	.07142	.06466
A2124	315.0	.6385	-.2419	-.0601	.12999	.07478	.06030
A2125	364.8	.6716	-.2519	-.0497	.12557	.07192	.05415
A2126	414.7	.7620	-.2920	-.0510	.10799	.07097	.05236
A2130	170.6	.5283	-.0059	-.0003	.09255	.06497	.06029
A2131	220.5	.5204	-.1694	.0039	.09187	.07300	.06024
A2132	267.7	.5760	-.0753	-.0010	.10664	.07329	.06294
A2133	317.6	.5784	-.0874	-.0056	.10623	.06805	.06324
A2134	367.5	.6251	-.1373	-.0016	.11693	.07478	.06451
A2135	417.3	.6709	-.1596	-.0155	.11790	.07358	.05990
A2140	131.2	.6418	-.1024	-.0632	.10442	.06272	.05245
A2141	187.7	.6561	-.1106	-.0589	.10401	.06485	.05408
A2142	237.5	.6239	-.1114	-.0457	.10078	.06202	.05478
A2143	287.4	.6649	-.1525	-.0375	.10261	.07213	.05981
A2144	337.3	.6633	-.1748	-.0337	.11024	.07805	.05921
A2145	387.1	.6741	-.1809	-.0289	.10889	.07657	.06084
A2150	35.4	.2888	-.5722	-.0151	.06273	.09638	.03000
A2151	78.7	.3435	-.6719	.0234	.05937	.08854	.04839
A2152	131.2	.5794	-.6776	.0189	.09197	.09130	.04817
B2160	35.4	.0869	-.2155	-.0300	.03631	.05658	.03419
B2161	60.4	.3967	-.3663	-.0142	.07034	.06375	.03990
B2162	110.2	.4404	-.4058	-.0170	.07546	.07084	.04751
B2163	160.1	.4827	-.4152	-.0225	.08008	.07240	.04554
B2170	304.5	.5153	-.3603	-.0990	.09684	.09655	.06032
B2180	350.4	.4465	-.2523	.0393	.08439	.08131	.07439
B2190	254.6	.5757	-.2523	-.0401	.10887	.07708	.07124
B2200	35.4	.5775	-.3018	.0212	.11473	.07915	.03984
B2201	65.6	.6511	-.3336	.0053	.10764	.07464	.05125
B2202	115.5	.6334	-.3549	-.0215	.10597	.07464	.05738
B2203	165.4	.6160	-.3663	-.0259	.10360	.07514	.05703
C2210	35.4	.4126	-.2610	.0023	.11106	.07224	.05603
C2211	85.3	.4653	-.2639	.0017	.13099	.07052	.05010
C2212	135.2	.5466	-.2463	.0061	.13878	.06623	.05937
C2220	397.6	.5757	-.2578	.0059	.08613	.05138	.04843
C2230	345.1	.5532	-.2889	-.0465	.07303	.05631	.04189
C2240	228.3	.2770	-.1162	-.0262	.09487	.05799	.06233
C2250	35.4	.8063	-.0767	.0175	.08654	.05140	.03157
C2251	85.3	.7954	-.1503	-.0011	.07635	.04450	.03942
C2252	135.2	.7918	-.1712	-.0107	.07793	.04749	.04330

WEST SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
F2260	35.4	-.4295	-.3969	.0803	.08707	.09542	.04970
F2261	85.3	-.4785	-.3855	.0497	.09425	.08539	.05173
F2262	135.2	-.5600	-.4073	.0342	.09710	.09362	.04643
F2264	185.0	-.5382	-.3376	.0329	.08831		.04052
F2270	353.0	-.4898	-.3372	.0305	.07859	.08616	.04300
F2280	359.6	-.6113	-.3149	.0034	.07317	.05837	.03759
F2290	232.3	-.5858	-.3138	.0334	.07104	.05106	.03851
F2300	35.4	-.3369	-.2113	.0131	.09259		.05031
F2301	74.8	-.4654	-.2464	.0187	.09698	.06765	.04589
F2302	124.7	-.5215	-.2809	.0299	.08571	.06286	.03827
F2303	172.6	-.5417	-.2877	.0292	.07812	.06280	.03992
G2310	35.4	.4222	-.2589	-.0242	.09026	.07130	.04308
G2311	85.3	.5521	-.2748	.0004	.08325	.05857	.04091
G2312	135.2	.5663	-.2626	.0094	.08343	.05417	.04762
G2320	168.0	.2958	.0270	-.0195	.08875	.05551	.05591
G2330	354.3	.6006	-.0440	-.0821	.10533	.05861	.07563
G2340	451.4	.7773	-.0792	-.0193	.07641	.04739	.04189
G2350	35.4	.7542	-.3054	.0262	.09847	.06802	.04696
G2351	85.3	.8039	-.2155	.0229	.07436	.05187	.04006
G2352	135.2	.8113	-.1967	.0186	.07158	.04799	.04120
H2360	35.4	.2536	-.0773	.0350	.10519	.03391	.04192
H2361	85.3	.2939	.0503	.0443	.09506	.06759	.05611
H2362	135.2	.3071	-.0208	.0360	.10464	.06087	.06376
H2370	254.6	.5104	-.0972	-.0660	.11560	.06498	.08195
H2380	590.6	.6592	-.2137	-.0662	.09089	.05098	.04905
H2390	481.6	.7234	-.1909	-.0096	.07264	.04701	.04207
H2400	35.4	.3466	-.2624	-.0344	.11197	.06906	.08067
H2401	85.3	.6814	-.2444	.0138	.07950	.05827	.03992
H2402	135.2	.7169	-.2487	.0290	.07157	.05253	.03950
I2410	35.4	.5712	-.5514	-.0395	.07178	.06209	.03581
I2411	85.3	.6442	-.5561	-.0171	.07015	.06078	.04210
I2412	135.2	.6513	-.5491	-.0139	.06837	.05497	.04341
I2420	357.0	.6855	-.4621	-.0475	.06897	.05350	.04578
I2430	472.4	.6061	-.4099	-.0154	.07230	.06747	.05426
I2440	206.0	.3381	-.3098	.0651	.07367	.06299	.05962
I2450	60.4	.2919	-.4106	.0261	.07959	.07399	.05994
I2451	110.2	.4521	-.4217	.0463	.08897	.08422	.05736
I2452	160.1	.5400	-.4229	.0470	.09217	.07054	.05280
J2460	322.8	.7515	-.0876	.0011	.08448	.05014	.04326
J2470	290.0	.6691	-.0599	.1208	.07405	.04573	.04046
J2480	140.4	.5619	-.2037	.1915	.08413	.06607	.05471

WEST SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
J2490	35.4	.5171	-.3482	.1174	.08550	.09092	.05020
J2491	85.3	.5861	-.3121	.0976	.10041	.08472	.06339
J2492	135.2	.6448	-.3267	.0864	.10353	.07470	.06829
K2500	259.8	.6775	-.2714	.0404	.07183	.04552	.04019
K2510	409.4	.6206	-.2632	.0363	.08521	.05654	.04863
K2520	237.5	.5089	-.3032	.0533	.09061	.06581	.05392
K2530	35.4	.3395	-.3146	-.0122	.10483	.07496	.04417
K2531	85.3	.4360	-.3014	.0184	.10130	.06893	.04858
K2532	135.2	.4889	-.3144	.0311	.10011	.06582	.05421
L2540	195.5	.5325	-.2913	.0231	.08464	.05345	.05645
L2550	498.7	.6415	-.3280	-.0081	.07174	.04126	.04014
L2560	255.9	.5609	-.2732	-.0097	.08362	.05790	.04824
L2570	35.4	.4136	-.2603	-.0266	.08612	.06030	.05346
L2571	85.3	.5836	-.3118	-.0052	.09142	.05777	.04546
L2572	135.2	.6467	-.3146	.0050	.08094	.05441	.04182
M2580	174.5	.5717	-.3239	.0077	.07313	.04447	.04030
M2590	378.0	.6127	-.3203	-.0044	.07496	.04401	.03835
M2600	119.4	.6276	-.2552	.0269	.07436	.05010	.04526
M2610	44.6	.5151	-.3131	.0323	.08905	.07233	.03852
M2611	94.5	.6081	-.3606	.0443	.07936	.06009	.04727
M2612	144.4	.6301	-.3729	.0340	.08117	.05875	.04427
N2620	35.4	.3574	-.1815	.0425	.07516	.04932	.05172
N2621	85.3	.4684	-.0905	.0712	.08888	.05890	.04471
N2622	135.2	.7227	-.0866	.0649	.08983	.05426	.04156
N2630	240.2	.6061	.0325	.1207	.07092	.05385	.06519
N2631	290.0	.5968	-.0023	.1051	.07236	.05478	.06960
N2632	339.9	.5830	-.0526	.0877	.07804	.05663	.07275
N2633	389.8	.6003	-.0774	.0693	.08817	.05783	.07706
N2634	439.6	.5928	-.1214	.0468	.09978	.06002	.07593
N2640	485.6	.7714	-.0308	-.0558	.09084	.06246	.05876
N2641	535.4	.7781	-.0398	-.0607	.08965	.06022	.05698
N2642	585.3	.8096	-.0484	-.0634	.08956	.05900	.05425
N2643	635.2	.8169	-.0611	-.0629	.08783	.05937	.05056
N2644	685.0	.8242	-.0676	-.0628	.08632	.05661	.04848
N2650	123.4	.3350	-.0369	-.0031	.13003	.07211	.08976
N2651	173.2	.4654	-.0409	-.0306	.15860	.08603	.10241
N2652	223.1	.5923	-.0494	-.0464	.15034	.08374	.09439
N2653	273.0	.7091	-.0462	-.0441	.11790	.07284	.07627
N2654	322.8	.7445	-.0356	-.0375	.08808	.05911	.05778
N2660	35.4	.3201	-.0320	-.0037	.09623	.05354	.05203
N2661	85.3	.5319	.0390	.0063	.12402	.08046	.07810
N2662	135.2	.6748	-.0246	.0039	.13138	.06932	.06954

WEST SOUTHWEST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
02670	49.9	.6318	-.3850	-.0405	.08830	.05167	.05100
02671	99.7	.7003	-.3965	-.0346	.07868	.05083	.03612
02672	149.6	.7055	-.3754	-.0329	.07458	.04756	.03617
02680	337.3	.5248	-.2661	-.0214	.12051	.06391	.08094
02690	534.1	.6275	-.4590	-.0376	.07970	.07241	.04570
02700	257.2	.6408	-.4600	.0760	.07664	.05557	.04167
02710	55.1	.5987	-.2769	.1165	.10898	.06370	.07448
02711	105.0	.6115	-.3974	.1245	.09217	.05227	.08937
02712	154.9	.6785	-.4025	.1233	.08221	.04986	.07038
P2720	44.6	.5071	-.3090	.0275	.10159	.08207	.03380
P2721	94.5	.6250	-.3407	.0516	.08938	.06887	.03793
P2722	144.4	.7073	-.2947	.0480	.09238	.06403	.04120
P2730	370.1	.7520	-.2677	-.0424	.08420	.05053	.04556
P2731	419.9	.7611	-.2673	-.0447	.08363	.05678	.04472
P2732	469.8	.7126	-.2547	-.0209	.09370	.06321	.04188
P2733	519.7	.7222	-.2693	-.0343	.08658	.05979	.04164
P2734	569.6	.7634	-.2765	-.0332	.09133	.06175	.04341
P2740	381.9	.6836	-.2935	-.0383	.08342	.05008	.04023
P2741	431.8	.7042	-.2871	-.0472	.08490	.05370	.04117
P2742	481.6	.6761	-.3016	-.0296	.08011	.05353	.03892
P2743	531.5	.6885	-.3364	-.0315	.07793	.06092	.04101
P2744	581.4	.6867	-.2993	-.0331	.08189	.05841	.04249
P2750	255.9	.3602	-.3084	-.1247	.11164	.10386	.09699
P2751	305.8	.3788	-.2685	-.1336	.12030	.09540	.08809
P2752	355.6	.4754	-.2333	-.1367	.14089	.09410	.09675
P2753	405.5	.6200	-.1913	-.1660	.14719	.09671	.09099
P2754	455.4	.6680	-.1591	-.1327	.13492	.09227	.06457
P2760	49.9	.5220	-.2568	-.0110	.12935	.07423	.06352
P2761	99.7	.6448	-.2697	.0064	.12558	.07344	.06281
P2762	149.6	.7021	-.2585	.0104	.10234	.06145	.05666
Q2770	35.4	-.1559	-.5976	.0838	.05270	.09640	.03898
Q2771	85.3	-.1140	-.6212	.0421	.04420	.10514	.05607
Q2772	135.2	-.1157	-.6511	.0267	.04140	.11036	.05892
Q2780	164.0	.0289	-.5670	-.0023	.02800	.08380	.05348
Q2790	182.4	.0832	-.5038	-.0164	.02958	.07340	.05756
Q2800	210.0	.0922	-.6046	.0097	.02740	.06837	.04998
Q2810	35.4	.1047	-.5769	.0160	.02929	.07407	.03462
Q2811	85.3	.1074	-.6240	.0110	.02792	.07545	.03703
Q2812	135.2	.1025	-.6380	.0068	.02686	.07053	.03684

WEST SOUTHWEST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9010	32.8	248.	.5548	-.0121	.07979	.04407	.03580
A9011	78.7	247.	.6502	-.0140	.07308	.04328	.03589
A9012	131.2	247.	.6947	-.0170	.07584	.04372	.03832
A9013	262.5	247.	.7708	-.0246	.07511	.04256	.03793
A9014	459.3	247.	.8306	-.0261	.06851	.04251	.03973
A9015	656.2	247.	.8843	-.0334	.06537	.04131	.03745
A9016	984.3	247.	.9497	-.0387	.05288	.03109	.02872
A9017	1312.3	247.	1.0017	-.0417	.02868	.01704	.01945
A9018	1968.5	247.	1.0337	-.0475	.01824	.00610	.00555
A9019	3280.8	247.	.9961	-.0475	.01806	.00761	.00582
A9210	35.4	247.	.3962	-.0310	.12315	.08055	.07021
A9211	78.7	250.	.6021	.0114	.11378	.07966	.06097
A9212	131.2	249.	.6601	.0261	.11753	.07664	.06237
A9213	262.5	247.	.7616	.0375	.12584	.07242	.05418
A9214	459.3	249.	.8663	.0345	.10466	.06307	.05122
A9215	656.2	248.	.8578	.0294	.09498	.05930	.05532
A9216	984.3	247.	.8822	.0219	.08865	.06282	.05498
A9217	1312.3	247.	.9150	.0144	.08943	.06345	.05654
A9218	1968.5	247.	.9878	.0082	.09003	.06000	.05729
A9219	3280.8	247.	.9962	.0230	.07410	.05240	.05028
A9210	4593.2	248.	1.0631	.0233	.05316		.03458
A9370	35.4	246.	.4899	.0237	.11795	.07264	.06169
A9371	78.7	248.	.5984	.0332	.12058	.06510	.05278
A9372	131.2	249.	.7308	.0412	.09814	.05542	.04044
A9373	262.5	248.	.7192	.0417	.09651	.04685	.04048
A9374	459.3	248.	.8083	.0382	.08258	.04789	.04110
A9375	656.2	247.	.8316	.0268	.07993	.04596	.04008
A9376	984.3	246.	.8497	.0143	.09854	.04534	.03541
A9377	1312.3	246.	.8921	.0072	.08715	.03906	.03331
A9378	1968.5	246.	.9758	.0042	.05687	.02722	.02518
A9379	3280.8	246.	.9911	.0051	.02923	.01499	.01981
A9840	35.4	243.	.4322	-.0272	.10994	.06534	.05623
A9841	78.7	246.	.5365	-.0367	.12892	.07041	.05885
A9842	131.2	248.	.6572	-.0335	.11956	.07230	.05096
A9843	262.5	248.	.6799	-.0274	.11661	.06583	.04948
A9844	459.3	248.	.7365	-.0292	.11109	.06776	.04834
A9845	656.2	248.	.7964	-.0191	.10726	.06648	.05018
A9846	984.3	248.	.8152	-.0173	.10497	.06205	.05394
A9847	1312.3	247.	.8242	-.0185	.11135	.06497	.05628
A9848	1968.5	248.	.8816	-.0180	.09934	.06055	.05762
A9849	3280.8	247.	.9669	-.0281	.05496	.03962	.04899
A9840	4593.2	247.	.9980	-.0297	.04387	.03575	.03279
A9860	35.4	243.	.6410	-.0151	.11893	.07358	.03800
A9861	78.7	243.	.7546	.0234	.11119	.07197	.04839
A9862	131.2	243.	.7603	.0189	.11640	.07362	.04817
A9863	262.5	244.	.7852	.0101	.10423	.07378	.04960
A9864	459.3	246.	.8078	-.0006	.11041	.06976	.05112
A9865	656.2	246.	.8419	-.0055	.11613	.06364	.05140
A9866	984.3	246.	.8510	-.0093	.11298	.05965	.04894
A9867	1312.3	247.	.9103	-.0176	.09782	.05233	.04945
A9868	1968.5	246.	.9384	-.0247	.07559	.04570	.04376
A9869	3280.8	247.	.9955	-.0273	.04363	.02836	.02747

NORTH NORTHEAST WIND DIRECTION

NORTH NORTHEAST WIND DIRECTION

NAME	ELEV.	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
A3110	85.3	.4486	.1329	-.0327	.11252		.04102
A3111	135.2	.5119	.1516	-.0537	.10966		.04562
A3130	267.7	.3688	.0750	-.0154	.07778		.04781
A3131	317.6	.3687	.1092	-.0128	.08167		.05328
A3132	367.5	.3889	.1152	-.0248	.08465		.05273
A3150	35.4	.4820	.1115	.0204	.10440	.09582	.05440
A3151	78.7	.5428	.1566	.0186	.10792	.08648	.05096
A3152	131.2	.5288	.1529	.0074	.10393	.07056	.05478
K3510	359.6	.4015	.0189	-.0531	.13014		.07263
K3511	409.4	.4228	.0572	-.0568	.13544		.07686
K3512	459.3	.4221	.0951	-.0499	.14275		.07960
K3530	35.4	.5374	.0919	.0051	.16907		.05231
K3531	85.3	.5470	.1233	-.0222	.14069		.06721
N3620	35.4	.2971	.1558	-.0585	.08647	.06293	.04824
N3621	85.3	.4524	.3347	-.0669	.11297		.04389
N3640	535.4	.3139	.1565	-.0435	.10963		.06684
N3641	585.3	.3029	.1510	-.0377	.10324		.06266
N3642	635.2	.3261	.1626	-.0449	.11023		.06959
P3720	44.6	.1974	.2416	-.0151	.09926	.12977	.03679
P3721	94.5	.2173	.2408	-.0106	.09365	.12880	.04675
P3740	431.8	.2514	.0585	-.0144	.11902	.06909	.05259
P3741	481.6	.2428	.0791	-.0143	.11572	.07440	.05042
P3742	531.5	.2320	.0730	-.0134	.11387	.06726	.05509

NORTH NORTHEAST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9110	35.4	24.	.5722		.09338	.07846	
A9111	78.7	25.	.6524		.10340	.08506	
A9112	131.2	25.	.6847		.09963	.08101	
A9113	262.5	24.	.7291		.10393	.09080	
A9114	459.3	23.	.7436		.09957	.08702	
A9115	656.2	24.	.7958		.10537	.08636	
A9116	984.3	23.	.7929		.11436	.08220	
A9117	1312.3	22.	.7998		.10740	.07950	
A9118	1968.5	21.	.8635		.11781	.08552	
A9119	3280.8	21.	.9061		.10451	.07285	
A9210	35.4	12.	.4515	-.0152	.11042	.08744	.04184
A9211	78.7	10.	.4626	-.0163	.11203	.08729	.06000
A9212	131.2	11.	.4772	-.0210	.11478	.07675	.06465
A9213	262.5	13.	.5125	-.0263	.11295	.07247	.06610
A9214	459.3	14.	.5146	-.0338	.11159	.07353	.07307
A9215	656.2	15.	.5290	-.0423	.11735	.07173	.08008
A9216	984.3	15.	.5483	-.0462	.12036	.07264	.08215
A9217	1312.3	18.	.5744	-.0582	.11433	.07693	.08773
A9218	1968.5	18.	.6122	-.0630	.12645	.07840	.09056
A9219	3280.8	21.	.6936	-.0780	.12829	.07248	.09301
A9370	35.4	9.	.2803	.0054	.12413	.07862	.03345
A9371	78.7	359.	.3442	-.0062	.13091	.08560	.05223
A9372	131.2	1.	.3498	-.0169	.12314	.08291	.05874
A9373	262.5	3.	.3678	-.0228	.13370	.07941	.07708
A9374	459.3	6.	.3818	-.0289	.13889	.07770	.08218
A9375	656.2	5.	.4171	-.0482	.13632	.08001	.09752
A9376	984.3	12.	.4376	-.0555	.14761	.09063	.11062
A9377	1312.3	14.	.4718	-.0664	.15401	.08977	.11314
A9378	1968.5	22.	.5467	-.0731	.17910	.09383	.13011
A9379	3280.8	25.	.7539		.15084	.07934	
A9840	35.4	14.	.4727	-.0391	.10480	.06378	.04637
A9841	78.7	14.	.5314	-.0542	.10103	.05780	.05772
A9842	131.2	17.	.5305	-.0546	.11045	.06176	.04965
A9843	262.5	18.	.5985	-.0600	.11420	.06475	.05586
A9844	459.3	18.	.6180	-.0639	.12000	.06229	.05783
A9845	656.2	18.	.7067	-.0844	.12058	.06063	.06085
A9846	984.3	20.	.7052	-.0698	.10609	.05489	.06616
A9847	1312.3	21.	.7302	-.0697	.09227	.04850	.06602
A9848	1968.5	20.	.8117	-.1011	.08457	.04100	.04974
A9849	3280.8	21.	.8661	-.0998	.04213	.02692	.03015
A9860	35.4	32.	.4904	.0204	.10171	.09022	.05440
A9861	78.7	31.	.5596	.0186	.10884	.08305	.05096
A9862	131.2	31.	.5534	.0074	.09746	.07058	.05478
A9863	262.5	20.	.5313	-.0105	.09924	.07344	.05917
A9864	459.3	19.	.5259	-.0206	.11198	.07017	.06072
A9865	656.2	17.	.5491	-.0427	.10058	.06257	.06682
A9866	984.3	16.	.6011	-.0625	.10712	.06359	.06603
A9867	1312.3	18.	.6178	-.0702	.10777	.06142	.06666
A9868	1968.5	18.	.6719	-.0956	.09628	.05950	.05839
A9869	3280.8	20.	.8288	-.0945	.07234	.04299	.04327

EAST NORTHEAST WIND DIRECTION

EAST NORTHEAST WIND DIRECTION

NAME	HEIGHT	U MEAN	V MEAN	W MEAN	U TURB	V TURB	W TURB
A4110	85.3	.3936	-.0156	-.0210	.11981	.07581	.04770
A4111	135.2	.4208	-.0167	-.0254	.12333	.07406	.04914
A4130	267.7	.3540	.0576	-.0004	.10572	.05610	.04443
A4131	317.6	.3323	.0350	.0052	.09896	.05470	.04591
A4132	367.5	.3639	.0237	.0059	.10540	.06528	.04895
K4510	359.6	.4754	-.0951	-.0682	.13088	.07232	.07342
K4511	409.4	.5037	-.1038	-.0715	.14108	.07341	.07695
K4512	459.3	.5209	-.1167	-.0729	.13935	.07432	.07694
K4530	35.4	.3871	-.1829		.11694	.09395	
K4531	85.3	.4519	-.1738		.12682	.08886	
N4620	35.4	.3461	-.1183		.13637	.09032	
N4621	85.3	.5564	-.1872		.14592	.08376	
N4640	535.4	.5886	-.0577		.15514	.07855	
N4641	585.3	.5842	-.0592		.13873	.07308	
N4642	635.2	.5854	-.0574		.14915	.07690	
P4720	44.6	.4420	-.1083		.13705	.09769	
P4721	94.5	.5161	-.1374		.14486	.10698	
P4740	431.8	.5412	-.0818		.14421	.06419	
P4741	481.6	.5424	-.0803		.13350	.06380	
P4742	531.5	.5504	-.0829		.13890	.06367	

EAST NORTHEAST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9010	35.4	65.	.6170		.08739	.04727	
A9011	78.7	64.	.7034		.08440	.05251	
A9012	131.2	64.	.7541		.08743	.05128	
A9013	262.5	64.	.8107		.08812	.05179	
A9014	459.3	65.	.8535		.08386	.05167	
A9015	656.2	64.	.8985		.08274	.05121	
A9016	984.3	64.	.9282		.07937	.05283	
A9017	1312.3	64.	.9390		.07412	.05169	
A9018	1968.5	63.	.9285		.06881	.05401	
A9019	3280.8	62.	.9344		.06881	.05824	
A9110	35.4	69.	.5421		.07479	.06612	
A9111	78.7	69.	.5836		.07453	.06438	
A9112	131.2	70.	.6152		.08030	.06985	
A9113	262.5	69.	.6518		.08703	.07333	
A9114	459.3	68.	.6705		.07553	.07147	
A9115	459.3	69.	.6955		.08249	.07271	
A9116	918.6	68.	.7038		.08506	.07307	
A9117	1312.3	69.	.7271		.08775	.07005	
A9118	1968.5	69.	.6998		.08906	.06948	
A9119	3280.8	68.	.7265		.09369	.07542	
A9110	4593.2	68.	.7592		.09173	.07127	
A9370	35.4	68.	.4881		.16276	.11651	
A9371	78.7	68.	.5562		.14424	.10579	
A9372	131.2	67.	.5958		.14468	.10306	
A9373	262.5	65.	.6195		.14120	.09310	
A9374	459.3	65.	.6988		.14140	.09137	
A9375	656.2	65.	.7850		.15330	.09566	
A9376	984.3	64.	.7421		.14703	.08605	
A9377	1312.3	64.	.7943		.15120	.09291	
A9378	1968.5	64.	.8284		.14059	.09234	
A9840	35.4	67.5	.4727		.15787		
A9841	64.6	67.5	.4775		.14184		
A9842	119.2	67.5	.4740		.13039		
A9843	250.1	67.5	.5068		.12278		
A9844	443.5	67.5	.5258		.13502		
A9845	644.0	67.5	.5233		.13443		
A9846	973.9	67.5	.5013		.12853		
A9847	1301.1	67.5	.5250		.13462		
A9848	1633.5	67.5	.5226		.13804		
A9849	1966.2	67.5	.5405		.14258		
A9840	2618.2	67.5	.5311		.14769		
A9841	3271.5	67.5	.5860		.15565		
A9842	4907.2	67.5	.8664		.13253		
A9843	5896.6	67.5	.9151		.06270		
A9844	7208.5	67.5	.9473		.02781		
A9845	9176.9	67.5	.9386		.01955		
A9846	11801.	67.5	1.0000		.02061		
A9847	14422.	67.5	.9908		.02000		
A9860	35.4	67.5	.6856		.18957		
A9861	62.8	67.5	.6649		.17665		
A9862	116.1	67.5	.6395		.16363		
A9863	247.8	67.5	.6655		.15735		
A9864	449.9	67.5	.7021		.16375		
A9865	644.7	67.5	.7071		.16674		
A9866	973.8	67.5	.6824		.16912		
A9867	1310.3	67.5	.6545		.16915		
A9868	1645.2	67.5	.7036		.18532		
A9869	1977.7	67.5	.6433		.17572		
A9860	2632.9	67.5	.6611		.16830		
A9861	3292.1	67.5	.7452		.17043		

EAST NORTHEAST WIND DIRECTION

NAME	ELEV.	AZIMUTH	SPEED	W MEAN	U TURB	V TURB	W TURB
A9862	4279.7	67.5	.8727		.13322		
A9863	5254.0	67.5	.9835		.07462		
A9864	6566.4	67.5	.9942		.03540		
A9865	8523.3	67.5	.9832		.01736		
A9866	10487.	67.5	.9866		.02606		
A9867	13111.	67.5	1.0000		.01500		
A9210	35.4	67.5	.4002		.17303		
A9211	62.6	67.5	.4227		.16067		
A9212	117.6	67.5	.4481		.16639		
A9213	253.9	67.5	.4687		.16324		
A9214	446.8	67.5	.4869		.16178		
A9215	644.2	67.5	.5211		.17388		
A9216	975.5	67.5	.5614		.17651		
A9217	1316.0	67.5	.6178		.18835		
A9218	1646.9	67.5	.6937		.19019		
A9219	1981.3	67.5	.7328		.18667		
A9210	2634.9	67.5	.8729		.15444		
A9211	3287.6	67.5	.9401		.12976		
A9212	4275.1	67.5	.9687		.07428		
A9213	5261.1	67.5	1.0000		.04110		
A9214	6555.5	67.5	.9966		.02572		
A9215	8516.8	67.5	.9846		.02134		
A9216	10486.	67.5	.9820		.01797		
A9217	13114.	67.5	.9720		.02171		
ATRG0	45.9	67.5	.9604		.11652		
ATRG1	63.6	67.5	.9718		.10816		
ATRG2	115.7	67.5	.9774		.08799		
ATRG3	250.9	67.5	.9717		.07641		
ATRG4	446.0	67.5	.9710		.06341		
ATRG5	642.8	67.5	.9872		.04751		
ATRG6	971.7	67.5	1.0000		.02503		
ATRG7	1298.7	67.5	.9794		.01807		
ATRG8	1629.0	67.5	.9792		.01512		
ATRG9	1957.2	67.5	.9503		.02169		
ATRG0	2613.3	67.5	.9393		.02011		
ATRG1	3269.6	67.5	.9268		.01938		
ATRG2	4253.6	67.5	.9179		.01485		
ATRG3	5238.4	67.5	.9175		.01051		
ATRG4	6547.3	67.5	.9184		.01486		
ATRG5	8515.6	67.5	.8963		.01602		
ATRG6	10484.	67.5	.8881		.02029		
ATRG7	13111.	67.5	.8952		.01141		
AFRG0	45.9	67.5	.5336		.08885		
AFRG1	65.7	67.5	.6019		.07947		
AFRG2	118.9	67.5	.6576		.07443		
AFRG3	253.0	67.5	.7343		.07622		
AFRG4	446.0	67.5	.7842		.07353		
AFRG5	644.5	67.5	.8388		.07288		
AFRG6	974.3	67.5	.9296		.05517		
AFRG7	1303.7	67.5	.9943		.03050		
AFRG8	1630.3	67.5	1.0000		.01815		
AFRG9	1956.4	67.5	.9777		.02592		
AFRG0	2615.0	67.5	.9609		.01939		
AFRG1	3269.5	67.5	.9517		.01846		
AFRG2	4253.1	67.5	.9452		.01444		
AFRG3	5237.5	67.5	.9362		.01450		
AFRG4	6553.3	67.5	.9457		.01423		
AFRG5	8514.1	67.5	.9389		.01741		
AFRG6	10487.	67.5	.9515		.01706		
AFRG7	13108.	67.5	.9536		.01570		